

# MYCOLOGIA

OFFICIAL ORGAN OF THE MYCOLOGICAL SOCIETY OF AMERICA

VOLUME XXXVI, 1944

CONSISTING OF I-IV+700 PAGES,  
INCLUDING FIGURES







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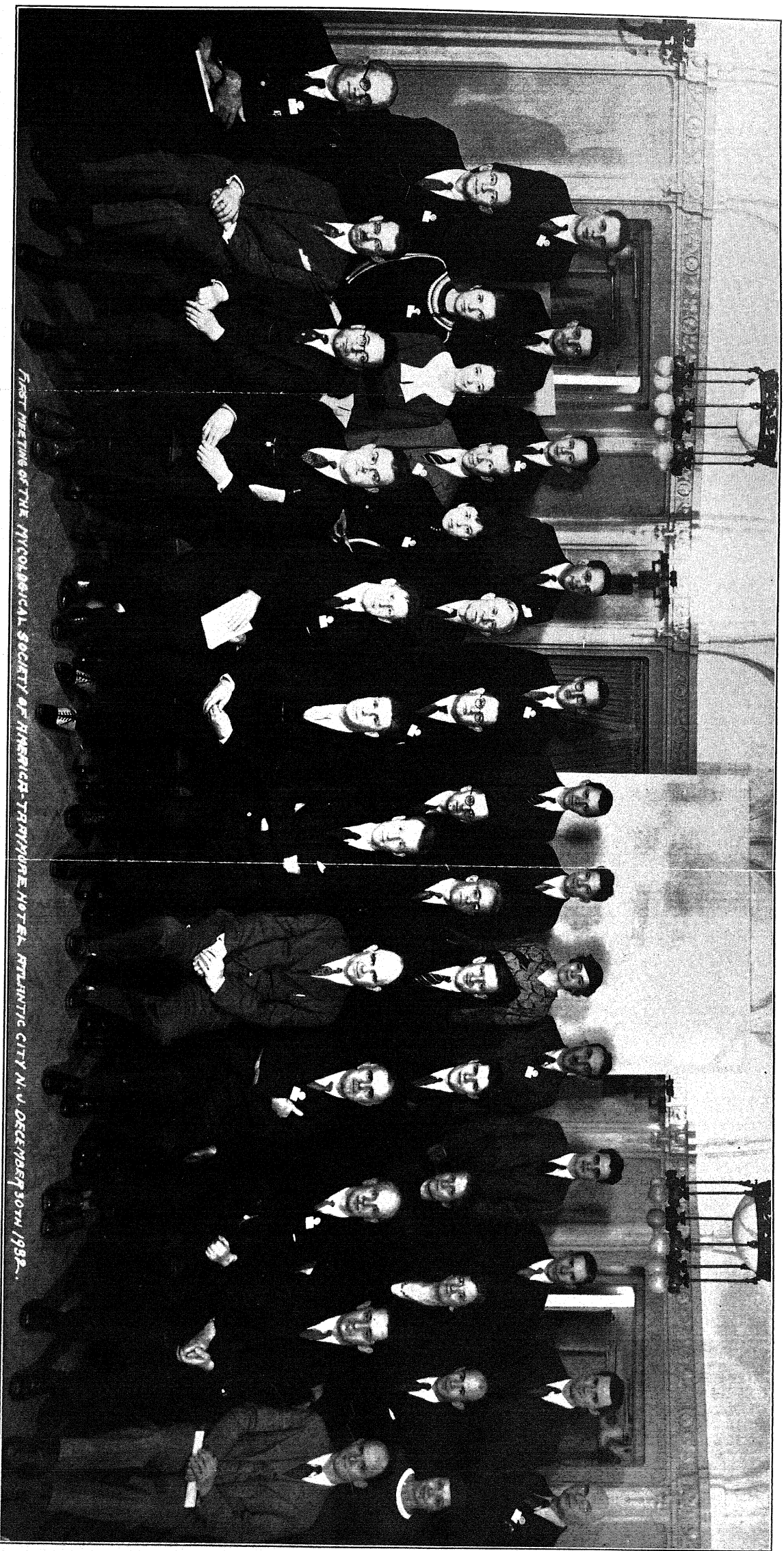
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*FIRST MEETING OF THE MYCOLOGICAL SOCIETY OF AMERICA—THAMPHRE HOTEL, ATLANTIC CITY N. J. DECEMBER 10TH 1932.*

*Top row*—K. A. Harrison, H. B. Bender, Don Creager, Michael Levine, G. A. Ledingham, Philip Rusden, M. L. Lohman, I. Elisabeth Astrom, G. E. Thompson, Norman Conant, Kenneth Raper, D. L. Gill, Don M. Benedict.  
*Middle row*—F. L. Drayton, Mrs. Don Creager, Mrs. L. M. Ames, Lawrence M. Ames, Evelyn Wells, J. B. S. Norton, George L. Zundel, J. C. Gilman, H. S. Cunningham, Cyril O. Bratley, Myron P. Backus, Grace E. Howard, Adelia McCrea, G. G. Hahn, Calista P. Elliot.  
*Bottom row*—R. D. Rands, P. W. Graff, L. H. Leonian, D. Swartz, C. Thom, F. J. Seaver, Wm. H. Weston, Jr., H. M. Fitzpatrick, H. S. Jackson, A. H. R. Buller, E. B. Mains, J. N. Couch.

This picture was taken at an hour which conflicted with an important session of another society and, consequently, it does not include all the mycologists who were present at Atlantic City.



# MYCOLOGIA

OFFICIAL ORGAN OF THE MYCOLOGICAL SOCIETY OF AMERICA

VOL. XXXVI JANUARY-FEBRUARY, 1944 No. 1

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## THE FIRST TWELVE YEARS OF THE MYCOLOGICAL SOCIETY OF AMERICA<sup>1</sup>

HARRY MORTON FITZPATRICK

(WITH GROUP PHOTOGRAPH)

At the second winter meeting of the Mycological Society of America, held at Boston, December 28-30, 1933, the office of Historian was established. An amendment to the Constitution was adopted there which reads: "The Council shall name a Historian to serve for an indeterminate period of years. It shall be the duty of the Historian to accumulate and preserve facts, papers, photographs, and other materials pertinent to a permanent historical record of the Society. The Historian shall not become a member of the Council by virtue of his office as Historian."

The office remained unfilled until late in December, 1936, when the writer became its first incumbent. Having served as Secretary-Treasurer of the Society during its first four years, he was already in possession of detailed records of that period. Also, he was thoroughly conversant with the viewpoints and events which had led to the formation of the new organization, and had just emphasized his interest in historical matters by giving, as Retiring President, an address entitled, "Historical Background of the Mycological Society of America" (*Mycologia* 29: 1). In accepting appointment to the new office and in giving considera-

<sup>1</sup> First report of the Society Historian, covering the years 1931-1943.

[MYCOLOGIA for November-December (35: 595-682) was issued  
December 1, 1943]



tion to the responsibilities involved, it seemed to him that the preservation of materials for the Archives should be regarded as constituting only one of his logical functions. It appeared desirable, in addition, that a complete and orderly record be kept of the vital statistics and essential activities of the organization, and that occasionally, perhaps at ten- or fifteen-year intervals, formal reports be published in which the scattered data of interest to the membership and posterity would be brought together. It was felt that a series of such reports, prepared by successive Historians, would constitute an index to accumulating materials of historical significance, some of which might otherwise be lost. It is hoped that some future Historian, possessed of the abilities that this distinguished title connotes, will be stimulated by the availability of these records to prepare a history of mycological endeavor and attainment in America.

Our Society is now in its twelfth year. Its tenth annual winter meeting was held at Dallas, Texas, in December, 1941. The meeting scheduled for New York City the following winter was cancelled at the request of the Federal Office of Transportation. Probably, we shall not be brought together again before the end of the war. In this interval of cessation of normal Society activities an especially favorable opportunity has been presented for preparation of a statement covering the affairs of our organization throughout somewhat more than the first decade of its existence. In attempting to make the report complete and accurate, we have felt that some of our contemporaries would approve of its preparation and find it a convenient source of reference. Though it is not unlikely that some others will regard the data incorporated as inconsequential, we have found justification for their inclusion in the realization that, had similar records of the activities of earlier groups of mycologists been carefully preserved, they would now be most valuable and interesting.

#### ARCHIVES

The task of accumulating photographs, letters, miscellaneous printed matter and other materials for permanent preservation in the Archives of the Society has been seriously undertaken. In 1937, a note was placed in *Mycologia* (29: 650) requesting

members to file all such desiderata with the Historian, especially photographs of groups and individuals in attendance at the various meetings. Though there has been a reasonably satisfactory response, many more such items should be deposited regularly.

At present the materials composing the Archives fill five volumes and occupy eight or ten inches of shelf space. The volumes have been bound uniformly, and are arranged as nearly as possible in chronological sequence. As the years pass it is hoped that others will be added to them. As such materials are largely irreplaceable, it has seemed to us that they should not pass from the hands of the Historian into those of his successors, lest in time through mishap they be lost. The Council has concurred in this viewpoint, and with its approval they have been placed on permanent deposit in the Library of the New York Botanical Garden with the definite understanding that, though available for consultation, they are not to be loaned.<sup>2</sup> Director William J. Robbins has accepted the volumes, and expressed the opinion that "as time passes original material of this type will become increasingly important."

The first volume is composed of the replies received to the questionnaire sent out by H. H. Whetzel in July 1931, in which he sought the opinion of American mycologists with respect to the desirability of establishing an independent mycological society to replace the Mycological Section of the Botanical Society of America. All the replies received are included. They present clearly the viewpoints held at that time by American botanists, mycologists and plant pathologists with respect to the need for such an organization. The vote was overwhelmingly in the affirmative, and led to the formation of the Society the following December. A critical tabulation of the vote was presented and discussed by the writer in *Mycologia* (29: 21). This volume of the Archives contains a similar resumé.

<sup>2</sup> In this action we have followed the precedent established by the Botanical Society of America in depositing at the New York Botanical Garden the two old volumes constituting the Proceedings and Register of the earlier Botanical Club of the American Association for the Advancement of Science (*Mycologia*, 29: 9). We have felt that such materials are more likely to be permanently preserved in an exclusively botanical library.

During the latter part of 1932, before and during the formal organization of the Society at Atlantic City, 243 individuals were enrolled as charter members. In late December, following the adoption of *Mycologia* as our official organ of publication, the Council ruled that all personal subscribers to the journal who should express the desire to join the Society during the early months of 1933 should also be included. Thirty-six did so. Though a relatively small number of individuals, assembled at New Orleans in December, 1931, had voted the Society into existence, the charter membership as thus defined embraces 279 names (*Mycologia* 26: 108; 29: 23). The second volume of the Archives includes only material concerned with the charter membership. It is composed chiefly of membership application blanks arranged in alphabetical order. These bear the signatures of most of the mycologists of this country and Canada.

The third volume is composed almost entirely of letters. These were written during the years 1931 to 1943 inclusive, but deal chiefly with the early days of the Society and with events which led to its formation. They total several hundred. They were written mostly by officers of the organization and by others who from time to time took an active part in its affairs. They have been arranged chronologically, and if read in that order reveal clearly the activities and influence of a number of individuals. Discrimination has been used in their selection, in the desire to avoid inclusion of personal matters or harmful materials. Various inclosures are scattered among them. In consequence, the volume contains a complete set of the mimeographed sheets distributed by the Secretary-Treasurer during the first year of the Society's existence, when funds were not yet available for printing. Similar mimeographed material, provided at the summer forays, is also included. The volume contains the preliminary draft of our Constitution and By-Laws and several tentative drafts of the contract between the Society and the New York Botanical Garden, framed while negotiations were under way looking toward the adoption of *Mycologia* as our official organ. The contract as finally drawn up, bearing the signatures of Director Elmer D. Merrill and the Secretary-Treasurer, accompanies their correspondence.

The fourth volume consists wholly of printed matter. It includes programs of the meetings, copies of the six Year Books issued for 1934-1939, membership lists printed subsequently in *Mycologia*, reprints of the presidential addresses, a set of the accompanying photographs of the Presidents, and other miscellaneous items such as amendments to the Constitution and reports on summer forays.

The fifth volume is of the nature of a portfolio and has been provided as a repository for photographic prints, picture post cards, newspaper clippings, sample ballots, and other miscellaneous written and printed matter of historical interest. The meetings of the Society constitute the units in connection with which this material has been arranged. The portfolio includes large, heavy, manila envelopes, one for each meeting to date, and in each of these the mementos of a single meeting have been filed. The writer is convinced that such an accumulation will, in time, have appreciable value. As to its interest for the younger generation of mycologists there can be no question. At the summer meeting of 1938, at Duchesnay, Quebec, and at that of 1939, at Gatlinburg, Tennessee, enlarged photographs were posted showing the groups in attendance at earlier forays. The keen interest with which these were scrutinized left no doubt of the desirability of preserving such records for the information and pleasure of those who shall follow after us. Already these pictures contain faces of beloved and distinguished members who will not again greet us at winter meeting or summer foray.

#### THE FIRST YEAR

The Mycological Society of America was founded at New Orleans, December 29, 1931, at the last business session of the Mycological Section of the Botanical Society of America, which thus terminated its own existence (*Mycologia* **24**: 246; *Science* **75**: 159). The action was taken in Room 213 of the Science Building of Tulane University, F. J. Seaver, chairman of the Section, presiding at the session. The group then elected an organizing committee of five members to serve during the following year. Its chairman, Wm. H. Weston, Jr., was designated the first President of the Society, the writer was selected to serve as

Secretary-Treasurer, and the other three members were chosen as Councilors. During 1932, this committee handled various problems of organization. An invitation was sent out urging all persons interested in the fungi to become charter members, and arrangements were made for holding the first meeting of the Society at Atlantic City in December in affiliation with the American Association for the Advancement of Science (*Mycologia* 24: 515). A tentative contract was drawn up with the New York Botanical Garden providing for adoption of *Mycologia* as the official organ of publication, and in November a mimeographed program (*Mycologia* 29: 650) was mailed in which an open business session for final organization of the Society was announced. All persons who had asked to be listed as charter members were invited to take an active part in the proceedings.

#### WINTER MEETINGS

The first winter meeting of the Society was held, December 28-30, 1932, at Atlantic City, with headquarters at the Traymore Hotel. At the open business session, under the chairmanship of President Weston, the organization of the Society was quickly accomplished with essentially unanimous votes on all motions introduced. The Constitution and By-Laws were approved, and officers for 1933 were elected (*Mycologia* 25: 66, 152). *Mycologia* was adopted and a new editorial board was chosen. Its members then elected F. J. Seaver editor-in-chief. The mycological sessions were well attended. The President gave as his retiring address a biographical sketch and eulogy of Roland Thaxter.<sup>3</sup>

Nine other winter meetings have been held, none of them having, of course, as great historical interest as the first. The mycological programs, throughout the decade, at times have contained papers of exceptional interest and importance. Publication of abstracts of the papers presented at the meetings has been successfully opposed from the beginning by the taxonomists who have experienced difficulties resulting from inclusion of new generic and specific names in such abstracts. It seems to the Historian, nevertheless, that some record of the content of papers

<sup>3</sup> Though Professor Thaxter had voted in favor of the formation of the Society, his death occurred in April, 1932, before he had become a member.

presented at the meetings should be preserved. As the programs have not been published in *Mycologia*, and as many members doubtless discard the copies provided in pamphlet form for use at the meetings, it has been especially desirable that a complete set of the latter be incorporated in the Archives.

Looking back over the programs of ten successive winter meetings, an increasing interest in certain phases of mycology and in various groups of the fungi is evident. Medical mycology has assumed a more prominent position, and a closer coöperation between the fields of medicine and taxonomic mycology has gradually developed. An increase in the number of students interested chiefly in the Phycomycetes has caused the scheduling in some years of a session given over exclusively to papers dealing with members of that group. Indeed, when there are so many competing, simultaneous programs of affiliated organizations, segregation of papers dealing with a limited interest has evident advantages. In works no hardship on members whose interests are broad, and will probably be increasingly evident in the sessions of the future.

At several meetings, significant business items have been handled. At Indianapolis in December 1937, the By-Laws (section 5) were amended to prohibit unauthorized use of the name of the Society for "advertising or other business ventures." At the last meeting, held at Dallas in 1942, article 5 of the Constitution was changed to provide that the Council shall contain four Councilors instead of two. It was designated also that two of these shall be from west of the Mississippi River and two from east of it, and that one from each region shall be elected annually.

From the beginning, it has been customary for the Retiring President to address the Society at the close of its open business session on the first day of the annual winter meeting. The address, accompanied by his portrait, is later printed in *Mycologia*. In Table I, a list of the winter meetings is given. In it the reference which follows the name of the President is to his address. The citations which follow the name of the city refer to official announcements and reports. In these the exact dates of the meetings are given, the headquarters hotels are named, and information concerning the sessions is provided.

TABLE I—WINTER MEETINGS

Year	City	President
1932	Atlantic City (Mycol. 24: 515; 25: 66, 152).	Wm. H. Weston Jr. <sup>6</sup> (Mycol. 25: 69).
1933	Boston (Mycol. 26: 197).	C. L. Shear (Mycol. 26: 201; 29: 732).
1934	Pittsburgh (Mycol. 27: 225).	H. S. Jackson (Mycol. 27: 553).
1935	St. Louis (Mycol. 28: 197).	B. O. Dodge (Mycol. 28: 399).
1936	Atlantic City <sup>4</sup> (Mycol. 28: 494).	H. M. Fitzpatrick (Mycol. 29: 1).
1937	Indianapolis (Mycol. 29: 651, 732).	John Dearness (Mycol. 30: 111, 692).
1938	Richmond <sup>5</sup>	L. O. Overholts (Mycol. 31: 629).
1939	Columbus <sup>5</sup>	H. H. Whetzel <sup>7</sup>
1940	Philadelphia <sup>5</sup>	D. H. Linder (Mycol. 33: 453).
1941	Dallas <sup>5</sup>	E. A. Bessey (Mycol. 34: 355).

<sup>4</sup> An outstanding feature of the second Atlantic City meeting, for some of the members in attendance, was a trip, spontaneously arranged, to a nearby mycological shrine, the old homestead of Job Bicknell Ellis at Newfield, New Jersey. An account of the trip with photographs of the house and the group which visited it appeared in *Mycologia* (29: 268).

<sup>5</sup> As reports on the meetings of 1938-1941 were not published, information concerning them should be sought in the programs. Also see *Year Book* for 1939 and *Mycologia* 33: 670.

<sup>6</sup> The portrait of President Weston does not accompany his address in *Mycologia*. It appeared the following year in connection with a eulogy of him prepared by F. A. Wolf (*Mycologia* 26: 113).

<sup>7</sup> President Whetzel was prevented by illness from preparing an address or attending the meeting. In his absence Vice-President Linder occupied the chair and gave an address (*Mycologia* 32: 419). Professor Whetzel's portrait appears as the frontispiece in volume 32 of *Mycologia*.

TABLE II—SUMMER FORAYS

Year	City	President
1933	Highlands, North Carolina (Mycol. 25: 233, 330, 550; 26: 195).	
1934	Seventh Lake near Inlet, New York (Mycol. 26: 277, 377; 27: 323).	
1935	Ithaca, New York (Mycol. 27: 327; 28: 98).	
1936	Mountain Lake, Virginia (Mycol. 28: 297; 29: 365).	
1937	Hanover, New Hampshire (Mycol. 29: 553; 30: 476).	
1938	Duchesnay, Quebec (Mycol. 30: 243; 31: 233, 728; 32: 264).	
1939	Gatlinburg, Tennessee (Mycol. 31: 234, 371; 33: 570).	
1940	Millinocket, Maine (Mycol. 32: 417; 34: 226).	
1941	Macdonald College, Quebec (Mycol. 33: 334; 34: 350).	

## FORAYS

At the organization of the Society at Atlantic City there was a very definite sentiment in favor of holding summer meetings. It was urged also that these be primarily of the nature of field excursions or collecting expeditions. Influenced by this viewpoint, the Council empowered the Vice-President to arrange for the first of these meetings for the summer of 1933. It was held in August at Highlands, North Carolina, was a successful and pleasant occasion, and established a pattern which has since been followed. Borrowing the name used by the British Mycological Society, the Highlands meeting was called the Mycological Foray. The name was not unfavorably received, and has been applied to all the following summer meetings. On the occasion of these forays, formal programs, usual at scientific assemblages, with presentation of papers based on the results of research, have been avoided. Morning excursions into the fields and forest are commonly followed by afternoon sessions in the laboratory. Identifications of collections are made for future listing in *Mycologia*, and the more interesting finds are preserved for deposit in the collectors' herbaria. As national authorities on various groups of fungi are usually in attendance, the younger students are afforded an exceptional opportunity for valuable contacts. Personal association, with exchange of opinions on fresh specimens at the time of their collection, is especially valuable to individuals engaged in the study of the same group of forms. Some students bring to the foray extensive collections of notes, photographs, and specimens for use in making comparisons with freshly collected materials. In the aggregate a considerable number of books are usually available, and, though the laboratory facilities are sometimes not wholly adequate, much worthwhile study is nevertheless accomplished.

Members attending the foray commonly come with wife, children, or friends. This gives the occasion a distinctly social aspect to which many look forward with considerable anticipation. As most of those who attend come in the family automobile, an interesting tour to points of non-mycological interest is often combined with the trip to the foray. In consequence of



these features the summer meeting has a value and charm not inherent in the winter program.

In selecting the place of meeting it has been necessary to keep in mind not only the desire for good collecting and a satisfactory laboratory but also the need for adequate facilities for feeding and housing such a gathering. Though primitive conditions in the wilds are satisfactory to some of the younger and more rugged collectors, they are distasteful to others. The majority who attend are willing to drive several hundred miles to reach the meeting place, but selection of more remote collecting grounds results in poor attendance. This has limited the choice thus far to the eastern United States and adjacent Canada. In the summer of 1938, headquarters were established at the Forest Rangers School at Duchesnay, Quebec, about 20 miles north of the City of Quebec. The following August the meeting was held at Gatlinburg, Tennessee, in the extreme eastern end of the State in the Great Smoky Mountains National Park. These two points mark the limits, north and south, of the territory within which all the forays have been held. In the future, in consideration of the expressed wish of some members who live a considerable distance from the Atlantic seaboard, the attempt should perhaps be made to hold an occasional foray in the Middle West, Far West, or Deep South. Nine mycological forays were held in the nine successive summers of the years 1933-1941 inclusive. War time limitations on private automobile travel and other means of transportation made it undesirable to attempt to hold meetings in 1942 and 1943.

It has been customary to print in *Mycologia* a statement of the plans for each coming foray, and to provide a report at its close in which a list of the fungi collected is included. These articles contain much detailed information of special interest to those who attend these summer meetings. As we have cited all of them in Table II, inclusion here of detailed discussion of individual forays is unnecessary.

#### MEMBERSHIP LISTS

Near the beginning of this paper, in the discussion of the Archives, a paragraph is included which provides information

concerning the charter membership. A list of the charter members, unaccompanied by addresses, was printed in *Mycologia* in 1934 (26: 108). It includes 279 names.

Following the organization of the Society in December, 1932, a year elapsed before sufficient funds had accumulated to defray the expense of printing an address list. In April, 1934, the first Year Book was distributed. In it, each member's name was given, accompanied by his title, address, and mention of his special mycological interest. The booklet also contained the text of the Constitution and By-Laws, the contract with the New York Botanical Garden concerning *Mycologia*, and the annual financial statement of the Secretary-Treasurer. The officers of the Society for 1932, 1933, and 1934 were listed, and a brief statement concerning the various meetings held up to that date was included. The total membership had then grown to three hundred and fifteen. Five additional Year Books were prepared for the years 1935-1939 inclusive. Except that the color of the cover was changed annually, they correspond rather closely with the first in content and aspect.<sup>8</sup> As a source of ready reference the little volume was a very useful addition to the desk of the American mycologist. However, as its annual preparation consumed considerable time and involved appreciable expenditure it was discontinued. In October, 1940, the Secretary-Treasurer mailed a statement to the members which reads: "The council has decided that instead of publishing a year-book each year the same list of members will be published once every three years in *Mycologia*. In this complete list the member's name, field of interest or research, and address will be published as in the yearbook. This list will appear in *Mycologia* sometime during 1941 and the necessary data will be called for later. However, interim lists of new members and changes of address will be published in the off years."

The first address list published under the new plan appeared in *Mycologia* (33: 670) in December, 1941, and was designated "Directory 1940-1941." The content is essentially the same as that of the Year Book except that an additional geographical

<sup>8</sup> The cover of the booklet for 1934 was designed by Don B. Creager. The drawing on those which followed was made by W. Lawrence White.

directory is provided in which the names in the alphabetical list are rearranged on the geographical basis. The Society, in 1941, had attained a membership of approximately four hundred, and had members in twenty-four countries. A year later a supplementary address list appeared with twenty-five additional names (*Mycologia* 34: 706). Loss in membership is to be expected during the period of the war, but efforts are being made to obtain new members to offset this as far as possible (*Mycologia* 34: 348).

#### CONCERNING MYCOLOGIA

The Society adopted *Mycologia* as its official organ of publication in December, 1932. It had been published throughout the preceding twenty-four years by the New York Botanical Garden, and a twenty-four year index was printed by the Garden, marking the end of the old regime (*Mycologia* 26: 477). At present, in 1943, the journal is in its thirty-fifth volume and its eleventh year under Society auspices. Strengthened by the support of the entire body of American mycologists, and aided by a growing endowment fund (*Mycologia* 26: 191; 27: 551; 29: 267; 30: 110; 31: 235; 32: 574; 34: 348) built up from private sources and from the sale of sets of the early volumes (*Mycologia* 28: 85; 30: 244), it has gradually increased in size and in the number of its illustrations.

*Mycologia* was established by the New York Botanical Garden, in 1909, to meet the need resulting from discontinuance of the *Journal of Mycology*. William Alphonso Murrill<sup>9</sup> served as its editor-in-chief throughout its first sixteen years. When he retired from the Garden staff in 1924, F. J. Seaver succeeded him in the editorship. Before the adoption of *Mycologia* by the Society, the cover<sup>10</sup> of the journal bore the names of a dozen or more American and foreign mycologists who had accepted the invitation of the editor-in-chief to serve with him as associate

<sup>9</sup> The index volume contains a frontispiece portrait of Doctor Murrill and a short historical statement covering the affairs of the journal throughout its first twenty-four years.

<sup>10</sup> A blue cover bearing the seal of the Garden had been used from the beginning. With adoption of the journal by the Society, the present brown cover was substituted, and the date of issue of the numbers was changed (*Mycologia* 25: 65).

editors. By the terms of our contract with the Garden a new editorial board came into existence. It consists of five members elected by the Council of the Society and a managing editor named by the Garden. This board of six editors elects an editor-in-chief annually. Doctor Seaver has now served the Society continuously for eleven years in the dual capacity of managing editor and editor-in-chief.

The membership of the first editorial board under Society auspices was announced by the Council, in December 1932, at Atlantic City, as follows:

F. J. Seaver—	Managing Editor
H. M. Fitzpatrick—	to serve only during 1933
J. A. Stevenson	—to serve during 1933–1934
F. A. Wolf	—to serve during 1933–1935
G. R. Bisby	—to serve during 1933–1936
E. B. Mains	—to serve during 1933–1937

Annually, thereafter, with the expiration of the term of office of a single editor, the Council has named a successor to serve for a five-year period. The following have been named to fill these vacancies.

G. W. Martin	—1934–1938
J. A. Stevenson	—1935–1939 (second term)
F. A. Wolf	—1936–1940 (second term)
J. N. Couch	—1937–1941 (resigned after serving 3 yrs.)
F. K. Sparrow	—1940–1941 (named for Couch's unexpired term)
S. M. Zeller	—1938–1942
H. S. Jackson	—1939–1943
J. A. Stevenson	—1940–1944 (third term)
J. H. Miller	—1941–1945
J. G. Hopkins	—1942–1946
A. H. Smith	—1943–1947

The board for 1943 consists of the last five in the list, and the managing editor.

#### OFFICERS OF THE SOCIETY

When the Society was voted into existence at New Orleans in December, 1931, officers were chosen to serve during 1932. They

were elected by those in attendance at the last business session of the Mycological Section of the Botanical Society of America, and constituted a committee empowered to complete the organization of the new Society. A year later, at the first business

TABLE III  
PAST AND PRESENT OFFICERS OF THE SOCIETY

PRESIDENT		VICE-PRESIDENT	
1932	Wm. H. Weston, Jr.	1933	G. W. Martin
1933	C. L. Shear	1934	B. O. Dodge
1934	H. S. Jackson	1935	John Dearness
1935	B. O. Dodge	1936	A. H. R. Buller
1936	H. M. Fitzpatrick	1937	L. O. Overholts
1937	John Dearness	1938	E. B. Mains
1938	L. O. Overholts	1939	D. H. Linder
1939	H. H. Whetzel	1940	E. A. Bessey
1940	D. H. Linder	1941	W. H. Snell
1941	E. A. Bessey	1942	J. N. Couch
1942	E. B. Mains	1943	F. D. Kern
1943	J. N. Couch		
SECRETARY-TREASURER		COUNCILORS	
1932-35	H. M. Fitzpatrick	1932	N. E. Stevens
1936-38	D. H. Linder	1932-33	H. S. Jackson
1939-41	J. N. Couch	1932-34	C. R. Orton
1942-44	G. B. Cummins <sup>11</sup>	1934-35	L. O. Overholts
		1935-36	C. L. Shear
		1936-37	B. O. Dodge
		1937-38	H. M. Fitzpatrick
		1938-39	Wm. H. Weston, Jr.
		1939-40	L. O. Overholts
		1940-41	H. H. Whetzel
		1941-42	F. D. Kern
		1942-43	D. H. Linder
		1943	F. D. Heald
		1943-44	E. B. Mains
		1943-44	C. W. Dodge
HISTORIAN			
1937-43	H. M. Fitzpatrick		

<sup>11</sup> W. W. Diehl was elected and his name appeared on the cover of the first issue of Mycologia for 1942. Being unable to serve, he resigned, and the Council then named G. B. Cummins to fill the vacancy.

session of the Society at Atlantic City, officers nominated by this committee were elected to serve during 1933. Also, a constitution was adopted which provided for nomination and election of officers, thereafter, by mail, and specified that ballots be sent by the Secretary-Treasurer to the entire membership. Beginning with the year 1934, this democratic method has been

followed. In Table III a complete list of the past and present officers of the Society is provided.

The Society names two representatives to serve on the Council of the American Association for the Advancement of Science. Similarly it has one representative on the National Research Council and one on the Editorial Committee of the American Journal of Botany. It also has several standing committees. The names of the representatives now acting and the present membership of these committees are listed in the Directory of the Society (*Mycologia* 33: 699). Earlier representatives are listed in the Year Books for 1937-1939 and in publications of the other organizations involved. The delegates of the Society at the Sixth International Botanical Congress at Amsterdam in 1935 were D. H. Linder, F. J. Seaver, and C. L. Shear (*Mycologia* 27: 226; 28: 92). We were represented on the council of the Third International Congress for Microbiology at New York in 1939 by W. C. Coker.

#### DEATHS

In the following list the attempt has been made to include the names of all deceased members of the Society. We hope that none has been inadvertently omitted. It has seemed appropriate to include also the names of a few who were not members, but whose passing was noted in *Mycologia* nevertheless. Most of these were distinguished mycologists who died shortly before or soon after the formation of the Society. The references provided are to obituaries or similar material.

- Arthur, Joseph Charles, b. 1850, d. 1942 (*Mycol.* 34: 601; *Phytopath.* 33: 428).  
 Banker, Howard James, b. 1866, d. 1940, not a member (*Mycol.* 33: 341).  
 Bartholomew, Elam, b. 1852, d. 1934 (*Mycol.* 27: 91).  
 Blackford, Mrs. Eliza B., b. 1849, d. 1935 (*Mycol.* 24: 247; Year Book for 1937).  
 Burnham, Stewart Henry, b. 1870, d. 1943 (*Science* 98: 318).  
 Burt, Edward Angus, b. 1859, d. 1939 (*Science* 89: 405; Year Book for 1939).  
 Clinton, George Perkins, b. 1867, d. 1937 (*Mycol.* 30: 481; *Phytopath.* 28: 304).  
 Davis, John Jefferson, b. 1852, d. 1937 (*Phytopath.* 28: 303; also see in volume 5 of the Archives a copy of Allen, Charles E., Birge, Edward A., Gilbert, Edward M. A tribute to Dr. J. J. Davis—with two portraits. Printed for private distribution by his daughter Marguerite Davis).  
 Fairman, Charles Edward, b. 1856, d. 1934 (*Mycol.* 27: 229, 328).  
 Forwood, Reginald, d. 1937 (Year Book for 1938).  
 Galloway, Beverly Thomas, b. 1863, d. 1938, not a member (*Mycol.* 30: 597).

- Goldsmith, Harry, b. 1889, d. 1939, teacher of biology and chemistry, and chairman of Science Department, Central High School, Newark, New Jersey (Year Book for 1939).
- Kauffman, Calvin Henry, b. 1869, d. 1931, not a member (Mycol. **23**: 407; **24**: 265; Phytopath. **22**: 271, 489).
- Kellerman, Karl Frederic, b. 1879, d. 1934, not a member (Mycol. **26**: 477).
- Kelly, Howard Atwood, b. 1858, d. 1943 (Mycol. **35**: 383; Science **97**: 176).
- Krieger, Louis Charles Christopher, b. 1873, d. 1940 (Mycol. **33**: 241; **35**: 383).
- Lewis, Mrs. Esther, d. 1934, joined the Society too late to be listed as a charter member and died before the Year Book for 1934 was issued (Mycol. **27**: 328; Year Book for 1935).
- Macbride, Thomas Huston, b. 1848, d. 1934 (Mycol. **26**: 379; **27**: 328).
- Miles, Lee Ellis, b. 1890, d. 1942 (Phytopath. **32**: 352).
- Puttemans, Arsene, d. 1937 (Year Book for 1938).
- Rosett, Joshua, b. 1875, d. 1940 (Mycol. **33**: 690).
- Seymour, Arthur Bliss, b. 1859, d. 1933, not a member (Mycol. **26**: 279; Phytopath. **24**: 576).
- Shimek, Bohumil, b. 1861, d. 1937 (Mycol. **29**: 364).
- Stevens, Frank Lincoln, b. 1871, d. 1934 (Mycol. **27**: 1, 328; Phytopath. **26**: 500).
- Taubenhaus, Jacob Joseph, b. 1884, d. 1937 (Phytopath. **28**: 305).
- Thaxter, Roland, b. 1858, d. 1933, not a member (Mycol. **25**: 69; Phytopath. **23**: 502, 565).
- Thomas, William Sturgis, d. 1940 (Mycol. **24**: 247; **35**: 133).
- Torrey, Raymond H., d. 1938 (Year Book for 1939).
- Van Hook, James M., b. 1870, d. 1935 (Phytopath. **26**: 501).

In assembling the data for the above list it was discovered that, in some instances, adequate obituary matter has not been published. It is not too late to do so, and colleagues of those who have not yet been thus honored are urged to submit material to *Mycologia*. Photographs, genealogical data, biographical matter, and a list of publications might well be filed with the Historian for permanent deposit in the Archives, in the case of every deceased member.

#### FUTURE RECORDS

The writer wishes to tender the thanks of the Society to those who have contributed materials for deposit in the Archives. Members should assume at all times the obligation of submitting historically interesting items without awaiting solicitation. Only with general coöperation can the Historian function effectively.

In conclusion, several suggestions are offered for consideration. As the Historian is not a member of the Council he does not have direct access to information concerning the actions taken by that

body. He is dependent on occasional notices printed in *Mycologia* or mailed to the members by the Secretary-Treasurer. Annual deposit in the Archives of a resumé of Council Proceedings, inclusive of all matters worthy of permanent recording, would seem to be desirable. Also some record should be made of the content of papers presented at the winter meetings. As publication of the abstracts is regarded as undesirable, the suggestion is made that they be deposited annually with the Historian by the Secretary-Treasurer. In a decade they would constitute a volume containing data not elsewhere available, and wholly worthy of a place in the series constituting the Archives.

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## GRAMINICOLOUS SPECIES OF PHYLLACHORA IN NORTH AMERICA<sup>1</sup>

C. R. ORTON

The studies upon which this work is based were initiated in 1916 at the New York Botanical Garden under the direction of Dr. F. J. Seaver when the writer was on leave from the Pennsylvania State College and while engaged in graduate work at Columbia University. More specifically it was an outgrowth of cytological studies on *Phyllachora graminis* under the direction of Professor R. A. Harper. The work was continued at the Pennsylvania State College until 1925 when the writer moved to New York to engage in research for the Bayer Company, Inc., and resumed at West Virginia University in 1929. At no time during these intermittent periods have these studies been pursued as a major task but wholly in an incidental manner outside official working hours. This comment is made to explain in part the long period which has been required to complete them to this point.

At first it was planned to monograph the genus *Phyllachora* but this idea was abandoned when it became evident that the species upon grasses were so numerous, and presented so many difficult problems that it seemed best to restrict this study to the grass-inhabiting forms in North America as delimited geographically in the "North American Flora."

Over all these years a large number of specimens has been studied. The collections at the New York Botanical Garden and the United States Department of Agriculture have been examined in considerable detail. In addition, herbaria of Harvard University, Pennsylvania State College, Cornell University, Michigan State College, Iowa State College, Universities of California, Wisconsin, Georgia, Nebraska, Illinois, Purdue, Louisiana State and Oregon State College have all contributed generously. No less notable has been the assistance rendered by those collectors who have faithfully sent collections, thus greatly enlarging the

<sup>1</sup>Scientific Paper No. 313 of the West Virginia Agricultural Experiment Station.

geographical distribution of numerous species and host ranges. In several instances such contributions have turned up species hitherto undescribed. The list of contributors includes H. H. Whetzel, C. E. Chardon, E. E. Bethel, J. J. Davis, Percy Wilson, John A. Stevenson, Roderick Sprague, Julian H. Miller, H. C. Greene, B. H. Davis, Lee Bonar, W. W. Ray, W. C. Cooke, C. L. Lefebvre, Dr. Carlos Garces O., Bogota, Colombia, and also Dr. Juan C. Lindquist, La Plata, Argentina, to whom the writer is especially indebted for furnishing types of Spegazzinian species. To all of these and many others who have aided in this work the writer wishes to express his heartiest thanks. The writer wishes particularly to acknowledge great obligation to Mrs. Agnes Chase who has never failed to give of her time and talents to the identification of host plants which in a majority of cases have been fragmentary and therefore most difficult to determine. The writer is further indebted to Berch Henry, a former graduate assistant, for aid and interest in the comparative studies.

The task of monographing a group of organisms if discriminatory is always difficult. In the present instance it has been difficult because of the absence of mature asci and ascospores in many of the collections, factors upon which chief reliance must be based. The other characters, particularly the clypeus, have been helpful but not wholly determinative. Furthermore the highly parasitic nature of the species on grasses and of the genus as a whole has made it impossible thus far to cultivate any one of them upon artificial media. In fact no authentic and controlled cultures upon host plants have been made and until the techniques of cultures are worked out no final estimate of specific limitations can be reached.

Another puzzling factor is the frequent association of pycnidiospores produced in apparently similar and closely associated fructifications. At present there is no proof that any of these asexual stages is phylogenetically connected with any *Phyllachora*, yet the circumstantial evidence points to such an association and the writer has included them in the specific descriptions where it seemed justified by association and other reasons. Such relationships must await cultural studies for final conclusion.

More conclusive is the presence in most, if not all species of bacilloid or allantoid bodies of small size; these are borne in pycnidia-like structures probably of a spermagonial nature, although their origin and functions have not been demonstrated. Finally the development of an adequate key to the species has been particularly difficult. The present effort is only a beginning.

In conclusion it seems necessary to discuss briefly the taxonomic status of *Phyllachora* in relationship with the known morphologic characters. The genus was established by Fuckel in 1869 and based upon *Sphaeria graminis* Pers. He placed it in the family Dothideaceae which was erected by him to include those forms with the ascocarp embedded in a stroma and lacking true perithecial walls. Without entering into the involved problem of the standing of the family Dothideaceae it may suffice to state that the writer's studies (1924), together with those of Petrak (1924) and Miller (1941) appear to justify amply the removal of the graminicolous phyllachoras from the Dothideaceae.

They should be placed in some family of the Sphaeriales characterized by a compound fructification in which an extension of the perithecial walls results in the formation of a plaque or clypeus overlying or underlying, or both, the usually numerous ascocarps which are typically embedded in the mesophyll leaf tissues and are formed successively in a peripheral manner. The compact pseudoparenchymatous walls are not true stromata but only resemble stromatic tissues and should not be confused with such forms as exist in *Catacauma flabella* for instance. Further ontogenetical studies must be made before certain other species included in the genus can be definitely and accurately placed in our classification of the fungi.

PHYLLACHORA Nitsch. in Fuckel, Symb. Myc. 216. 1869

*Diachora* J. Muell. Bot. Centralb. 57: 346. 1894.

*Pseudomelasmia* Henn. Hedwigia 41: 115. 1902.

*Metachora* Syd. & Butler, Ann. Myc. 9: 400. 1911.

*Endophyllachora* Rehm, Philipp. Jour. Sci. 7: 397. 1913.

Fructification parasitic, foliicolous, simple or usually compound on maturity, made up of few to numerous ascocarps generally crowded together in the mesophyll so that their lateral walls form

a dark-brown palisade-like tissue when viewed in cross section; the apical and basal regions of the ascocarps usually extended radially or in the direction of the leaf axis to form a blackish clypeus more or less conspicuous in the epidermal region of one or both leaf surfaces; ascocarps opening by an ostiole through the overarching clypeus; paraphyses filiform; asci cylindrical to broadly ellipsoid, operculum not usually conspicuous; ascospores 1-celled, hyaline, variously arranged. Conidia of uncertain phylogeny and borne in similar fructifications are rather constantly present in some species, variously shaped; spermatia (?) short-filiform, rather commonly present

Type species: *Phyllachora graminis* on *Elymus europeus*.

#### KEY TO SPECIES

1. Ascospores arranged uniseriately in the ascus.  
(ascospores arranged biseriately, see p. 23).
2. Ascospores spherical or sub-spherical.
  3. Ascospores averaging 7.5 by 10  $\mu$ . 11. *P. sphaerosperma*.
  3. Ascospores averaging 8 by 12  $\mu$ . 28. *P. Ammophilae*.
  3. Ascospores averaging 10.5 by 16  $\mu$ . 37. *P. Spartinae*.
2. Ascospores ovoid.
  3. Ascospores broadly ovoid, average ratio width to length less than 1-2  $\mu$ . 37. *P. Spartinae*.
  3. Ascospores narrowly ovoid, average ratio width to length 1-2 or greater.
    4. Asci elliptical, 12-20  $\mu$  wide 4. *P. quadraspora*.
    4. Asci cylindrical.
      5. Asci 8-10  $\mu$  wide. 40. *P. Eragrostidis*.
      5. Asci 10-15  $\mu$  wide. 13. *P. Eriochloae*.
2. Ascospores ellipsoid.
  3. Ascospores broadly ellipsoid, ratio width to length less than 1-2  $\mu$ .
    4. Ascospores small, 7.5-11  $\mu$  long.
      5. Clypei oval to elliptical in outline. 34. *P. Boutelouae*.
      5. Clypei elliptical to fusiform in outline. 27. *P. Phalaridis*.
      5. Clypei irregular in outline. 25. *P. insularis*.
  4. Ascospores of medium size, 9-13  $\mu$  long.
    5. Asci narrowly cylindrical, 8-12  $\mu$  wide.
      6. Asci 60-80  $\mu$  in length.
        7. Clypei circular to oval in outline.
          8. Clypei 0.5-1.0 by 0.5-1.5 mm. 23. *P. parilis*.
          8. Clypei 0.1-0.3 by 0.2-0.8 mm. 24. *P. paspalicola*.

- |   |                               |
|---|-------------------------------|
| 7. Clypei oval to fusiform in outline.  | 17. <i>P. Wilsonii</i> .      |
| 6. Asci longer, 70–100 $\mu$ long.  |                               |
| 7. Clypei circular in outline, large.   | 1. <i>P. Maydis</i> .         |
| 7. Clypei oval in outline, small.   | 6. <i>P. brevifolia</i> .     |
| 7. Clypei elliptical to linear.   | 42. <i>P. graminis</i> .      |
| 6. Asci 80–115 $\mu$ long.  |                               |
| 7. Clypei elliptical to linear, large.  | 5. <i>P. luteo-maculata</i> . |
| 5. Asci broader, 10–15 $\mu$ wide.  |                               |
| 6. Clypei mostly circular in outline.   | 9. <i>P. Anihephorae</i> .    |
| 6. Clypei oval to elliptical in outline scattered.                              | 12. <i>P. macorisensis</i> .  |
| 6. Clypei elliptical to linear in outline, gregarious and frequently confluent. | 36. <i>P. serialis</i> .      |
| 4. Ascospores larger, mostly 12–17 $\mu$ long.                                  |                               |
| 5. Asci 10–15 $\mu$ wide.   | 28. <i>P. Ammophilae</i> .    |
| 5. Asci 15–20 $\mu$ wide.   |                               |
| 6. Clypei amphigenous, small, less than 1 mm. long.                             | 10. <i>P. Arundinellae</i> .  |
| 6. Clypei chiefly epiphyllous, larger.  | 3. <i>P. nervisequia</i> .    |
| 3. Ascospores narrowly ellipsoid, average ratio width to length 1–2 or greater. |                               |
| 4. Ascospores small, 7.5–10 $\mu$ long.   | 18. <i>P. guianensis</i> .    |
| 4. Ascospores medium sized, 9–13 $\mu$ long.                                    |                               |
| 5. Clypei circular to broadly oval in outline.                                  | 24. <i>P. paspalicola</i> .   |
| 5. Clypei oval to elliptical in outline.  |                               |
| 6. Clypei not more than 0.5 mm. wide.   |                               |
| 7. On Paniceae.   | 15. <i>P. punctum</i> .       |
| 7. On Festuceae.  | 40. <i>P. Eragrostidis</i> .  |
| 6. Clypei up to 1.0 mm. wide.   | 30. <i>P. vulgata</i> .       |
| 5. Clypei oval to fusiform in outline, up to 2.0 mm. long.                      | 17. <i>P. Wilsonii</i> .      |
| 5. Clypei elliptical to linear in outline.                                      |                               |
| 6. Clypei large, up to 5 mm. long.  | 42. <i>P. graminis</i> .      |
| 6. Clypei small, not more than 1 mm. long.                                      | 36. <i>P. serialis</i> .      |
| 4. Ascospores large, mostly 12–20 $\mu$ long.                                   |                               |
| 5. Clypei circular to oval in outline.  | 41. <i>P. silvatica</i> .     |

5. Clypei oval to elliptical in outline.
  6. Ascospores 10-15  $\mu$  long. 13. *P. Eriochloae*.
  6. Ascospores 13-18  $\mu$  long. 7. *P. Erianthi*.
5. Clypei long-elliptical to linear in outline.
  6. Clypei amphigenous.
    7. Ascospores 13-16  $\mu$  long. 31. *P. texensis*.
    7. Ascospores 15-20  $\mu$  long. 32. *P. coloradensis*.
  6. Clypei chiefly epiphyllous.
    7. Ascospores 11-14  $\mu$  long. 33. *P. Oryzopsidis*.
    7. Ascospores 17-22  $\mu$  long. 46. *P. tetraspora*.
2. Ascospores ovate-acuminate.
  3. Ascospores narrow, 5-6  $\mu$  wide. 35. *P. Leptochloae*.
  3. Ascospores broader, 6-8  $\mu$  wide.
    4. Ascospores 11-16  $\mu$  long (8-spored form). 4. *P. quadraspora*.
    4. Ascospores 15-23  $\mu$  long.
    5. On Paniceae.
      6. Asci 4-spored. 19. *P. tetrasporicola*.
      6. Asci 8-spored. 20. *P. cornispora*.
      5. On Agrostideae. 29. *P. Epicampedis*.
    3. Ascospores large, 7.5-9.5 by 20-26  $\mu$  (4-spored form). 4. *P. quadraspora*.
  2. Ascospores fusiform.
    3. Ascospores narrow, 4.5-6  $\mu$  wide.
    4. Ascospores 10-14  $\mu$  long. 38. *P. Pammelii*.
    4. Ascospores 14-19  $\mu$  long. 35. *P. Leptochloae*.
    3. Ascospores broader, 5.5-8.5  $\mu$  wide.
      4. Ascospores 15-22  $\mu$  long.
      5. Asci cylindrical, 8-10  $\mu$  wide. 19. *P. tetrasporicola*.
      5. Asci cylindrical to ellipsoid, 10-18  $\mu$  wide. 20. *P. cornispora*.
      4. Ascospores 12-16  $\mu$  long. 41. *P. silvatica*.
  1. Ascospores arranged biserially or inordinately.
    2. Ascospores ovoid.
      3. Ascospores narrow, 4-5  $\mu$  wide. 14. *P. Lasiacis*.
      3. Ascospores broader, 6-9.5  $\mu$  wide.
        4. Ascospores 11-16  $\mu$  long (8-spored form). 4. *P. quadraspora*.
        4. Ascospores 17-26  $\mu$  long.
        5. Asci 15-20  $\mu$  wide.
          6. Ascospores 17-23  $\mu$  long. 8. *P. oxyspora*.
          6. Ascospores 20-26  $\mu$  long (4-spored form). 4. *P. quadraspora*.
        5. Asci 20-25  $\mu$  wide. 45. *P. portoricensis*.
    2. Ascospores ellipsoid.
      3. Ascospores broadly ellipsoid, ratio width to length less than 1-2.
      4. Ascospores 6.5-8 by 12-15  $\mu$ . 16. *P. Chardonii*.

3. Ascospores narrowly ellipsoid, ratio width to length 1-2 or greater.
  4. Clypei mostly hypophyllous.
    5. Ascospores 4.5 to 5.5  $\mu$  wide. 39. *P. diplocarpa*.
    5. Ascospores 6.0-7.5  $\mu$  wide. 41. *P. silvatica*.
  4. Clypei amphigenous.
    5. Clypei not greater than 0.5 by 1.0 mm.
    6. Clypei brown. 2. *P. tripsacina*.
    6. Clypei black.
      7. Asci cylindrical-clavate, 55-75  $\mu$  long. 26. *P. Leersiae*.
      7. Asci cylindrical, 75-100  $\mu$  long. 43. *P. Arundinariae*.
    5. Clypei up to 1.0 by 2.0 mm. 21. *P. heterospora*.
  2. Ascospores ovate-acuminate.
    3. Asci mostly 9-15  $\mu$  in width (sometimes wider *P. cornispora*).
    4. Clypei oval to elliptical in outline.
      5. Clypei small, up to 0.5 mm. wide by 1.5 mm. long. 20. *P. cornispora*.
      5. Clypei larger, up to 1.0 mm. wide by 3.0 mm. long. 35. *P. Leptochloae*.
    4. Clypei elliptical to linear in outline.
      5. Ascospores medium sized, 4-5 by 9.5-13  $\mu$ . 14. *P. Lasiacis*.
      5. Ascospores large, 6-8 by 19-23  $\mu$ . 25. *P. Epicampedis*.
    3. Asci 15-25  $\mu$  wide.
      4. Ascospores large, 7-9 by 12-23  $\mu$ . 8. *P. oxyspora*.
      4. Ascospores very large, 9-10 by 30-38  $\mu$ . 44. *P. excelsior*.
  2. Ascospores fusiform.
    3. Ascospores narrow, 4.5-6  $\mu$  wide.
      4. Asci short, 40-70  $\mu$  long. 22. *P. congruens*.
      4. Asci of medium length, 70-95  $\mu$ .
        5. Ascospores 10-14  $\mu$  long. 38. *P. Pammelii*.
        5. Ascospores 15-19  $\mu$  long. 35. *P. Leptochloae*.
    3. Ascospores of medium width, 6.0-8.5  $\mu$ .
      4. Clypei 0.1-0.4 by 0.1-0.8 mm. 43. *P. Arundinariae*.
      4. Clypei 0.4-0.8 by 0.5-1.0 mm. 41. *P. silvatica*.
    3. Ascospores very large, 9-10 by 30-38  $\mu$ . 44. *P. excelsior*.
1. PHYLLACHORA MAYDIS Maubl. Bull. Soc. Myc. France 20: 72. 1904.

Clypei amphigenous, generally circular in outline, 0.5-2 mm. across, sometimes confluent to form continuous stripes up to 10 mm., black; fructification compound, ascocarps nearly spherical, immersed in the mesophyll; asci cylindrical, 8-10 by 80-100  $\mu$ , with a short pedicel; 8 ascospores broadly ellipsoid, 5.5-7 by 9-12  $\mu$ , uniseriate.

On Poaceae:

*Zea Mays* L. Dominican Republic; Guatemala; Mexico; Puerto Rico.

TYPE LOCALITY: Mexico on *Zea Mays*.

DISTRIBUTION: Mexico, the West Indies and Northern South America.

2. *PHYLLACHORA TRIPSACINA* Pet. & Cif. Ann. Myc. 30: 253. 1932.

Clypei amphigenous but more prominent on upper surface, oval to elliptical in outline, 0.1–0.5 mm. wide by 0.2–1.0 mm. long, rarely confluent, blackish brown; fructification compound, ascocarps nearly spherical, immersed in the mesophyll; asci long elliptical, 15–20 by 90–110  $\mu$ , with a long tapered pedicel; 8 ascospores, ellipsoid to fusoid, 6.5–7.5 by 16–19  $\mu$ , biseriate or in-ordinate.

On Poaceae:

*Tripsacum dactyloides* (L.) L. Dominican Republic.

TYPE LOCALITY: Sabana de Guerra, Dominican Republic.

DISTRIBUTION: Known only from Dominican Republic.

3. *Phyllachora nervisequia* (Schw.) comb. nov.

*Sphaeria nervisequia* Schw. Trans. Am. Phil. Soc. II. 4: 208. 1832.

*Sphaeria Andropogi* Schw. Trans. Am. Phil. Soc. II. 4: 209. 1832.

*Phyllachora Andropogi* Ellis & Ev. N. Am. Fungi 2828. 1893.

Clypei chiefly epiphyllous, scattered, oval to elliptical, black, 0.3–0.5 mm. wide by 0.5–1.3 mm. long, rarely 1 mm. wide and confluent to form stripes up to 4.5 mm. long; fructification compound; asci cylindrical to narrowly ellipsoid, 15–19 by 95–125  $\mu$ ; 8 ascospores, broadly ellipsoid, 7–8.5 by 12–17  $\mu$ , usually uniseriate.

On Poaceae:

*Andropogon bicornis* L. Puerto Rico.

*Andropogon Elliotii* Chapm. South Carolina.

*Andropogon glomeratus* (Walt.) B.S.P. Florida, Georgia, Texas; Dominican Republic; Puerto Rico.

*Andropogon longiberbis* Hack. Alabama, Florida.



*Andropogon ternarius* Michx. Alabama, Georgia.

*Andropogon* sp. Louisiana, Mississippi, Pennsylvania, Virginia.

TYPE LOCALITY: Bethlehem, Pennsylvania, on *Andropogon* sp.

DISTRIBUTION: Pennsylvania to Florida and the West Indies.

4. PHYLLACHORA QUADRASPORA Tehon, Bot. Gaz. 67: 507. 1919.

Clypei amphigenous but more conspicuous on lower surface, scattered or gregarious in areas up to 2 cm. in length, elliptical in outline, 0.1–0.3 wide by 0.3–1.0 mm. long; fructification simple or compound; asci narrowly ellipsoid to cylindrical, 15–20 by 75–110  $\mu$ ; 8-ascospore form with uniseriate, biseriate or inordinate arrangement, ascospores narrowly ovoid, 6–8 by 11.5–16; 4-ascospore form with uniseriate or biseriate arrangement, ascospores narrowly ovoid to ovate acuminate, 7.5–9.5 by 20–26; conidia lunate, 1-septate, 2.5–3.0 by 23–40  $\mu$ .

On Poaceae:

*Andropogon bicornis* L. Puerto Rico.

*Andropogon fastigiatus* Sw. (*Diectomis fastigiatus* H.B.K.). Mexico.

*Andropogon leucostachyus* H.B.K. Dominican Republic; Panama; Puerto Rico.

*Andropogon semiberbis* (Nees) Kunth. Dominican Republic; Puerto Rico.

*Andropogon* sp. Florida.

*Rotboellia rugosa* Nutt. Mississippi.

TYPE LOCALITY: Maricao, Puerto Rico on "*Paspalum glabrum*" error for *Andropogon semiberbis*.

DISTRIBUTION: Mississippi to Panama, the West Indies and South America.

5. PHYLLACHORA LUTEO-MACULATA (Schw.) Orton, Jour. Dept. Agr. Puerto Rico 2: 152. 1918.

*Sphaeria andropogonicola* Schw. Trans. Am. Phil. Soc. II. 4: 209. 1832.

*Sphaeria luteo-maculata* Schw. Trans. Am. Phil. Soc. II. 4: 209. 1832.

Clypei amphigenous but more conspicuous on upper leaf surface, elliptical to linear, scattered, but sometimes confluent, 0.2–1.2 mm. wide by 0.5–6.0 mm. long, black; fructification com-

pound; asci cylindrical, 9–12 by 75–115  $\mu$ ; 8 ascospores, broadly ellipsoid, 5–7.5 by 9–12  $\mu$ , uniseriate; conidia in similar fructifications, 3-septate, cylindrical, 3–3.5 by 18–20  $\mu$ .

On Poaceae:

*Andropogon furcatus* Muhl. (*A. provincialis* var. *furcatus* Hack.). Illinois, Massachusetts, Michigan, Nebraska, New York, South Dakota, Wisconsin.

*Andropogon Hallii* Hack. New Mexico.

*Andropogon perforatus* Trin. Texas.

*Andropogon saccharoides* Swartz. Texas.

*Andropogon Virginicus* L. Alabama, Louisiana, New Jersey, North Carolina, Virginia.

*Andropogon* sp. South Carolina.

*Schizachyrium scoparium* (Michx.) Nash (*Andropogon scoparius* Michx.). Georgia, Massachusetts, Minnesota, Pennsylvania, Virginia.

*Sorghastrum nutans* (L.) Nash. Iowa.

TYPE LOCALITY: South Carolina on *Andropogon* sp.

DISTRIBUTION: Massachusetts to Nebraska and southward to South Carolina and New Mexico.

EXSICCATI: Ellis & Ev. N. Am. Fungi 2828; Griff. W. Am. Fungi 39. Cooke, Mycob. N. Am. 91.

6. *PHYLLACHORA BREVIFOLIA* Chardon, Jour. Dept. Agr. Puerto Rico 13: 11. 1929.

Clypei amphigenous, oval to broadly elliptical in outline, scattered, rarely confluent, 0.2–0.4 mm. wide by 0.3–1.0 mm. long, black; fructification simple or compound with few ascocarps; asci cylindrical, 8–12 by 65–100  $\mu$ ; 8 ascospores, broadly ellipsoid, 5.5–7 by 10.5–13  $\mu$ , uniseriate.

On Poaceae:

*Andropogon brevifolius* L. Puerto Rico.

TYPE LOCALITY: Rio Piedras, Puerto Rico on *Andropogon brevifolius* L.

DISTRIBUTION: The West Indies and South America.

7. *Phyllachora Erianthi* sp. nov.

Clypei amphigenous, scattered or sometimes gregarious in large patches, chiefly oval in outline, rarely confluent, 0.1–0.6 mm.

wide by 0.2–1.0 mm. long, black; fructification simple or compound with few ascocarps; asci cylindrical, 9–15 by 75–115  $\mu$ ; 8 ascospores, narrowly ellipsoid, 6–8 by 13–18  $\mu$ , uniseriate; conidia borne in similar fructifications, cylindrical, 3-septate, 4 by 23  $\mu$ . Spermatia (?) thread-like, 0.5 by 15–20  $\mu$ , often curved.

On Poaceae:

*Erianthus alopecuroides* (L.) Ell. (*E. divaricatus* Hitchc.).

South Carolina.

*Erianthus brevibarbis* Michx. Florida, Georgia.

*Erianthus contortus* Ell. Georgia.

*Erianthus giganteus* (Walt.) Muhl. Alabama, Florida.

TYPE LOCALITY: Alabama on *Erianthus* sp.

DISTRIBUTION: South Carolina to Alabama.

EXSICCATI: Ravenel, Fungi Am. 388.

8. *PHYLLACHORA OXYSPORA* Starb. Bih. Sv. Vet.-Akad. Handl. 25: 45. 1900.

*Phyllachora Cyperi* var. *obtusata* Starb. Bih. Sv. Vet.-Akad. Handl. 25: 1899.

*Phyllachora Imperatae* Syd. Ann. Myc. 15: 226. 1917.

*Phyllachora antioquensis* Chardon, Bul. Real Soc. Esp. Hist. Nat. 28: 118. 1928.

*Phyllachora Sorghastri* Chardon, Jour. Dept. Agr. Puerto Rico 16: 177. 1932.

Clypei amphigenous, scattered or gregarious, oval to fusoid in outline, 0.2–1.0 mm. wide by 0.3–2.0 mm. long, sometimes confluent to form larger patches, black; fructification mostly compound with few ascocarps; asci ellipsoid, 15–20 by 90–120  $\mu$ ; 8 ascospores, narrowly ovoid to ovate-acuminate, 7–9 by 17–23  $\mu$ , generally biseriate; conidia in similar fructifications cylindrical, 1-septate, 2.5–3.5 by 20–27  $\mu$ .

On Poaceae:

*Imperata brasiliensis* Trin. Dominican Republic.

*Imperata contracta* (H.B.K.) Hitchc. Puerto Rico.

*Sorghastrum parviflorum* (Desv.) H. & Ch. Dominican Republic.

TYPE LOCALITY: San Paolo, Brazil, on unknown grass [*Imperata brasiliensis*].

DISTRIBUTION: West Indies, South America and the Philippines.

9. *PHYLLACHORA ANTHEPHORAE* Sydow, Ann. Myc. 13: 39. 1915.

Clypei amphigenous, more conspicuous on upper surface, scattered, circular or broadly oval in outline, prominently convex on both surfaces, 0.1–0.25 mm. wide by 0.1–0.4 mm. long, black; fructification simple or compound with few ascocarps; asci cylindrical, 10–14 by 70–100  $\mu$ ; 8 ascospores broadly ellipsoid, 5.5–7.5 by 10–13.5  $\mu$ , uniseriate.

On Poaceae:

*Antheophora hermaphrodita* (L.) Kuntz. Dominican Republic; Jamaica; Puerto Rico.

TYPE LOCALITY: Kingston, Jamaica on *Antheophora hermaphrodita*.

DISTRIBUTION: West Indies and South America.

10. *Phyllachora Arundinellae* sp. nov.

Clypei amphigenous, generally gregarious, more rarely scattered, oval to elliptical in outline, 0.1–0.3 mm. wide by 0.3–0.8 mm. long, black; fructification chiefly simple; asci cylindrical to narrowly ellipsoid, 17–20 by 95–115  $\mu$ ; 8 ascospores, broadly ellipsoid, 7–8 by 13–15.5  $\mu$ ; uniseriate; conidia associated in similar fructifications, fusoid, 2-celled, 2–2.5 by 10.5–17  $\mu$ .

On Poaceae:

*Arundinella confinis* (Schult.) Hitchc. & Chase (*A. martinecensis* Trin.). Puerto Rico.

TYPE LOCALITY: Maricao, Puerto Rico on *Arundinella confinis*.

DISTRIBUTION: Known only from Puerto Rico.

11. *PHYLLACHORA SPHAEROSPERMA* Winter, Hedwigia 23: 170. 1884.

*Phyllachora sphaerospora* Pat. Bull. Soc. Myc. France 3: 126. 1887 (in part).

*Phyllachora cenchricola* Speg. Anal. Mus. Nac. Buenos Aires 12: 245. 1909.

*Sphaerodothis sphaerosperma* (Winter) Stev. & Moore. Ill. Biol. Monog. 11: 43. 1927.

Clypei amphigenous, broadly oval, rarely elliptical in outline, often thickly scattered over considerable areas of the leaf, 0.15–0.4 mm. wide by 0.2–0.8 mm. long, black; fructification generally compound; asci cylindrical, 10–13 by 65–100  $\mu$ ; 8 ascospores, nearly spherical, 7–8.5 by 8–11  $\mu$ , uniseriate; conidia associated in similar fructifications, fusoid to lunar, 1 to 3-septate, 3–4 by 24–34  $\mu$ .

On Poaceae:

*Cenchrus echinatus* L. California; Bahama Islands (Berry Island); Cuba; Puerto Rico.

*Cenchrus incertus* M. A. Curtis. Mississippi.

*Cenchrus myosuroides* H.B.K. Mona Island.

*Cenchrus viridis* Spreng. Canal Zone; Cuba; Jamaica; Puerto Rico.

TYPE LOCALITY: São Francisco, Brazil, on *Cenchrus echinatus*.

DISTRIBUTION: Southern United States, West Indies and in South America.

12. *PHYLLACHORA MACORISENSIS* Chardon, Jour. Dept. Agr. Puerto Rico 13: 14. 1929.

Clypei amphigenous, oval to elliptical in outline, generally scattered, 0.3–0.5 mm. wide by 0.5–1.2 mm. long, black, not shiny; fructification generally compound; asci cylindrical-clavate, 8–12 by 75–90; 8 ascospores, ellipsoid, 5–6.5 by 10–15  $\mu$ ; uniseriate.

On Poaceae:

*Stenotaphrum secundatum* (Walt.) Kuntze.

TYPE LOCALITY: San Pedro de Macoris, Dominican Republic on *Stenotaphrum* [secundatum].

DISTRIBUTION: Known only from type locality.

13. *PHYLLACHORA ERIOCHLOAE* Speg. Anal. Soc. Ci. Argent. 19: 96. 1885.

*Phyllachora Eriochloae* var. *columbiensis* Thiess. & Syd. Ann. Myc. 13: 448. 1913.

Clypei amphigenous, oval to elliptical in outline, scattered, sometimes confluent, 0.2–0.3 mm. wide by 0.2–1.0 mm. long, shiny black; fructification simple or compound with few ascarps; asci cylindrical, 10–15 by 75–115  $\mu$ ; 8 ascospores, narrowly ovoid to ellipsoid, 5–7 by 10–15  $\mu$ , uniseriate; spermatia (?) sinuate, 0.5–1.0 by 11–15  $\mu$ , continuous.

On Poaceae:

*Eriochloa punctata* (L.) Desv. Puerto Rico.

*Eriochloa subglabra* (Nash) Hitchc. Puerto Rico.

TYPE LOCALITY: Santiago, Argentina, on *Eriochloa annulata*.

DISTRIBUTION: West Indies and South America.

14. PHYLLACHORA LASIACIS Syd. Ann. Myc. 23: 374. 1925.

Clypei amphigenous, gregarious, interveined, elliptical to linear in outline, 0.1–0.2 mm. wide by 0.1–1.2 mm. long, sometimes laterally confluent; fructification simple or compound with numerous ascocarps; asci long, ellipsoid, 9–12 by 55–75  $\mu$ ; 8 ascospores, narrowly ovoid, or ovate-acuminate, 4–5 by 9.5–13  $\mu$ , biseriate; conidia (?) present in similar fructifications, ellipsoid, 1–1.5 by 3.5  $\mu$ , hyaline, continuous.

On Poaceae:

*Lasiacis divaricata* (L.) Hitchc. Costa Rica.

*Lasiacis Swartziana* Hitchc. Puerto Rico.

TYPE LOCALITY: San José, Costa Rica, on *Lasiacis divaricata*.

DISTRIBUTION: West Indies and South America.

15. PHYLLACHORA PUNCTUM (Schw.) Orton, Stevenson, Jour. Dept. Agr. Puerto Rico 2: 153. 1918.

*Sphaeria punctum* Schw. Trans. Am. Phil. Soc. II. 4: 209. 1832.

*Sphaeria Panici* Schw. Trans. Am. Phil. Soc. II. 4: 209. 1832.

*Phyllachora Panici* Sacc. Syll. Fung. 2: 624. 1883.

*Phyllachora graminis* var. Tupi Speg. Anal. Soc. Ci. Argent. 19: 241. 1885.

*Phyllachora graminis Panici* Shear, Ellis & Ev. Fungi Columb. 1752. 1903.

*Phyllachora Oplismeni* Syd. Ann. Myc. 5: 339. 1907.

*Phyllachora Standleyi* Chardon, Jour. Dept. Agr. Puerto Rico 16: 174. 1932.

*Phyllachora Panici-olivacei* Chardon, Bol. Soc. Venez. Cien. Nat. 40: 21 (?). 1939.

Clypei amphigenous, scattered, oval to elliptical, often arranged in linear series, sometimes coalescing to form lines several millimeters long, 0.1–0.4 mm. wide by 0.15–1.5 mm. long, more rarely gregarious, black, shining; fructification simple or more

generally compound containing several ascocarps; asci cylindrical, 8–10 by 75–90  $\mu$ ; 8 ascospores, ellipsoid, 4–5.5 by 9–13  $\mu$ , generally with a prominent guttule, uniseriate; conidia in similar fructification, fusiform, often curved, 1–3 septate, 2–4 by 12–20  $\mu$ ; spermatia (?) small, 0.5 by 7.5–9.5  $\mu$ , often curved.

On Poaceae:

*Leptoloma cognatum* (Schult.) Chase. Texas, Wisconsin.

*Oplismenus Burmanni* (Retz.) Beauv. Costa Rica.

*Oplismenus hirtellus* (L.) Beauv. South Carolina; Cuba; Dominican Republic; Haiti; Puerto Rico.

*Oplismenus Humboldtianus*. Costa Rica.

*Oplismenus setarius* (Lam.) R. & S. Florida, Louisiana; Jamaica; Puerto Rico; St. Croix; Dominican Republic.

*Panicum boreale* Nash. New Hampshire.

*Panicum Boscii* Poir. Florida, Georgia, Illinois, Kentucky, Michigan, Missouri, New York, Wisconsin.

*Panicum clandestinum* L. Delaware, District of Columbia, Georgia, Indiana, Iowa, Maryland, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Virginia, West Virginia.

*Panicum commutatum* Schuler. Georgia, Mississippi.

*Panicum consanguinem* Kunth. Georgia.

*Panicum depauperatum* Muhl. Virginia.

*Panicum dichotomum* L. Illinois, Michigan, New York, Texas.

*Panicum flavovirens* Nash. Florida.

*Panicum Helleri* Nash. Texas.

*Panicum Huachucae* Ashe. Arkansas, Delaware, Virginia, Wisconsin.

*Panicum implicatum* Scribn. Ontario.

*Panicum Joorii* Vasey. Florida, Louisiana.

*Panicum lancearium* Trin. Florida.

*Panicum lanuginosum* Ell. Arkansas, Delaware, Louisiana, Virginia.

*Panicum latifolium* L. Delaware, Illinois, Indiana, Iowa, Kentucky, Michigan, Missouri, New York, Ohio, West Virginia, Wisconsin.

*Panicum Lindheimeri* Nash. Indiana, Louisiana, Wisconsin.

*Panicum linearifolium* Scribn. Texas; Ontario.

*Panicum microcarpon* Muhl. Alabama, Georgia, North Carolina, Virginia.

*Panicum pacificum* Hitchc. & Chase. California.

*Panicum pedicellatum* Vosey. Texas.

*Panicum scabriusculum* Ell. Alabama, Georgia.

*Panicum scoparium* Lam. Alabama.

*Panicum Scribnerianum* Nash. Alabama, Nebraska, Wisconsin.

*Panicum sphaerocarpon* Ell. Pennsylvania, Virginia, West Virginia; Honduras; Puerto Rico.

*Panicum tennesseense* Ashe. Iowa, Wisconsin; Ontario.

*Panicum Wrightianum* Scribn. New York.

*Panicum xalapense* H.B.K. Georgia, Mississippi; Guatemala.

TYPE LOCALITY: Bethlehem, Pennsylvania, on *Panicum nitidum*, probably error for *P. clandestinum*.

DISTRIBUTION: New England to Ontario, south to Texas and Florida, the West Indies and South America.

EXSICCATI: Kellerm. Ohio Fungi 51; Ellis & Ev. Fungi Columb. 1752; Rehm, Ascomycetes 1973; Barth. Fungi Columb. 3645; Ellis, N. Am. Fungi 484; Sydow, Fungi Exot. 516; Cooke, Mycob. N. Am. 90.

16. *Phyllachora Chardonii* Orton; Seaver & Chardon, Sci. Sur. Puerto Rico & Virgin Is. 3: 51. 1926.

Clypei chiefly epiphyllous, scattered, circular to oval in outline, 0.2–0.3 mm. wide by 0.3–0.5 mm. long, black; fructification simple or compound, perithecia-flattened globose; asci ellipsoid, 12–22 by 65–110  $\mu$ ; 8 ascospores, broadly ellipsoid, 6.5–8 by 12–15, usually biseriate or inordinate.

On Poaceae:

*Panicum geminatum* Forsk. Florida; Puerto Rico.

TYPE LOCALITY: Puerto Rico on *Panicum geminatum*.

DISTRIBUTION: Southern United States, West Indies and the Philippines.

17. *Phyllachora Wilsoni* sp. nov.

Clypei amphigenous, scattered, oval to fusiform in outline, 0.2–1.0 mm. wide by 0.3–2.0 mm. long, cinereous to black; fruc-



tification compound with numerous ascocarps; asci cylindrical, 9–12 by 60–85  $\mu$ ; 8 ascospores, ellipsoid 4.5–7 by 9.5–13  $\mu$ , uniseriate; spermatia (?) in similar fructifications, filiform 0.5–1.0 by 12–18  $\mu$  continuous; conidia in similar fructifications 2.0 by 23–30  $\mu$ , 3-septate, slightly curved.

On Poaceae:

*Panicum obtusum* H.B.K. New Mexico, Oklahoma.

*Paspalum ciliatofolium* Michx. Alabama, Florida, Georgia.

*Paspalum epile* Nash. Alabama.

*Paspalum Muhlenbergii* Nash. Alabama, Virginia.

*Paspalum pubescens* Muhl. Illinois, Missouri, North Carolina, Virginia.

*Paspalum pubiflorum* var. *glabrum* Vasey. Texas.

*Paspalum setaceum* Michx. Alabama, District of Columbia, New Jersey, South Carolina.

*Paspalum stramineum* Nash (*P. Bushii* Nash). Nebraska, Oklahoma, Texas, Wisconsin.

*Paspalum supinum* Bosc. Missouri.

*Paspalum* sp. Louisiana; Mississippi.

TYPE LOCALITY: Ocean Gate, New Jersey on *Paspalum setaceum*. (Wilson 792)

DISTRIBUTION: New York to Nebraska and south to New Mexico and Alabama.

EXSICCATI: Barth. Fungi Columb. 2742; Rabenhorst-Winter, Fungi Europaei 3061 (A).

18. PHYLLACHORA GUIANENSIS Stev. Ill. Biol. Monog. 8: 19. 1923.

*Physalospora Panici* Rehm, Hedwigia 40: 114. 1901.

*Phyllachora Panici* Theiss. & Syd. Ann. Myc. 13: 452. 1915.  
(Not *P. Panici* (Schw.) Sacc.)

*Phyllachora microspora* Chardon, Bol. Real. Soc. Esp. Hist. Nat. 28: 119. 1928.

*Phyllachora Paspali-virgati* Chardon, Jour. Dept. Agr. Puerto Rico 13: 14. 1929.

*Phyllachora Leonardi* Chardon, Myc. Explor. Venez. Monog. Univ. Puerto Rico, Ser. B. 2: 157. 1934.

Clypei amphigenous, but more conspicuous on upper leaf surface, scattered, oval, rarely confluent, 0.15–0.3 mm. wide by

0.2–1.0 mm. long, black; fructification generally simple, occasionally compound; asci cylindrical, 8–10 by 55–70  $\mu$ ; 8 ascospores, narrowly ellipsoid, 3.5–5.0 by 7.5–11  $\mu$ , uniseriate; conidia sometimes present in similar fructifications, narrowly ellipsoid, 2-celled, 2.0–2.5 by 9.5–12  $\mu$ , hyaline.

On Poaceae:

*Panicum laxum* Sw. Puerto Rico.

*Paspalum ciliatifolium* Michx. Florida.

*Paspalum clavuliferum* Wright. Dominican Republic.

*Paspalum laeve* Michx. Louisiana.

*Paspalum virgatum* L. Puerto Rico; Cuba; Jamaica.

TYPE LOCALITY: Georgetown, British Guiana on *Paspalum virgatum*.

DISTRIBUTION: Gulf States, West Indies, Central and South America.

19. *Phyllachora tetrasporicola* Chardon, sp. nov.

Clypei amphigenous, more prominent on lower surface of leaf, scattered, circular to oval in outline, more rarely elongated and confluent; 0.3–0.5 mm. wide by 0.5–1.0 mm. long; fructification compound with few ascocarps, black and shiny; asci cylindrical, 8–10 by 65–85  $\mu$ ; 4 ascospores, fusiform to ovate-acuminate, 6–7 by 15–19  $\mu$ , uniseriate.

On Poaceae:

*Panicum pilosum* Swartz. Dominican Republic.

TYPE LOCALITY: Duarto Road, District Nacional, Dominican Republic. (Chardon 654)

DISTRIBUTION: Known only from type locality.

20. *PHYLLACHORA CORNISPORA* Atk. Bull. Cornell Univ. **3**: 11. 1897.

*Phyllachora acuminata* Starb. Archiv. Bot. **51**: 11. 1905.

*Phyllachora Chaetochloae* Stev. Ill. Biol. Monog. **8**: 19. 1923.

*Phyllachora cornispora-necrotica* Chardon, Bol. Real. Soc. Esp. Hist. Nat. **28**: 116. 1928.

*Phyllachora Ortonii* Chardon, Jour. Dept. Agr. Puerto Rico **13**: 11. 1929.

*Phyllachora Murilloi* Garces, Caldasia, No. 2, 86. 1941.

Clypei amphigenous but often more prominent on upper leaf surface, circular or oval to ellipsoid in outline, 0.15–0.5 mm. wide

by 0.5–1.5 mm. long, sometimes confluent to form lines up to 7 mm. long, occasionally forming oval necrotic spots several millimeters long, black; fructification usually compound with numerous ascocarps; asci cylindrical, rarely ellipsoid or saccate, 10–18 by 65–125  $\mu$ ; 8 ascospores, ovate-acuminate, more rarely fusiform 5.5–8.5 by 15–22  $\mu$ , biseriate or uniseriate; conidia fusiform, often curved, 3–4 by 25–35  $\mu$ , 2-celled; spermatia (?) cylindrical, filiform, 0.5 by 17–25  $\mu$ , continuous.

On Poaceae:

*Chaetochloa setosa* (Sw.) Scrib. Dominican Republic.

*Panicum agrostoides* Spreng. Alabama, Illinois.

*Panicum anceps* Michx. Georgia.

*Panicum glutinosum* Sw. Canal Zone.

*Panicum longifolium* Torr. Alabama.

*Paspalum distichum* L. Florida.

*Paspalum fasciculatum* Willd. Costa Rica.

*Paspalum laeve* Michx. Florida.

*Paspalum laxum* Lam. Puerto Rico.

*Paspalum millegrana* Schrad. Puerto Rico.

*Paspalum notatum* Flugge. Puerto Rico.

*Paspalum virgatum* L. Guatemala; Panama; Puerto Rico.

TYPE LOCALITY: Auburn, Alabama on *Panicum agrostoides*.

DISTRIBUTION: Southern United States; Central and South America; West Indies.

21. PHYLLACHORA HETEROSPORA P. Henn. DeWild. Mission E. Laurent 1: 362. 1907.

*Phyllachora Raciborskii* Theiss. & Syd. Ann. Myc. 13: 453. 1915.

*Phyllachora seriata* Theiss. & Syd. Ann. Myc. 13: 453. 1915.

*Phyllachora Vanderystii* Theiss. & Syd. Ann. Myc. 13: 455. 1915.

Clypei amphigenous, gregarious, circular to oval, rarely elliptical in outline, 0.2–1 mm. wide by 0.2–2 mm. long, often arranged in linear series up to 5 mm. long, black; fructification simple or compound with numerous ascocarps; asci ellipsoid to saccate, 12–22 by 75–125  $\mu$ ; 8 ascospores, narrowly ellipsoid, 6.5–7.5 by 13–19  $\mu$ , uniseriate or biseriate and sometimes inordinate.

On Poaceae:

*Pennisetum distachyum* (Four.) Rupr. Costa Rica.

TYPE LOCALITY: Congo, Africa, on *Panicum maximum*.

DISTRIBUTION: Central and South America; Africa; Java; Philippines.

22. PHYLLACHORA CONGRUENS Rehm, Leaf. Philipp. Bot. 6: 2220. 1914.

*Phyllachora microstroma* Chardon, Bol. Real Soc. Esp. Hist. Nat. 28: 118. 1928.

Clypei amphigenous or sometimes epiphyllous, circular or oval in outline, scattered, 0.1–0.3 mm. wide by 0.15–0.5 mm. long, sometimes confluent to form linear series up to 1 mm., black; fructification simple or compound with few ascocarps; asci ellipsoid, 10–15 by 40–70  $\mu$ ; 8 ascospores, fusiform or sometimes rounded at one end, 4.5–6 by 11–15  $\mu$ , biseriate.

On Poaceae:

*Panicum hians* Ell. Alabama.

*Panicum longifolium* Torr. New Jersey.

*Paspalum conjugatum* Berg. Puerto Rico.

*Paspalum saccharoides* Nees. Panama.

TYPE LOCALITY: Los Banos, Laguna, Philippine Islands, on *Panicum carinatum*.

DISTRIBUTION: New Jersey along coast to Texas, the West Indies, South America, South Africa and the Philippines.

23. PHYLLACHORA PARILIS Syd. Ann. Myc. 25: 3–4. 1927.

Clypei amphigenous but more conspicuous on lower leaf surface, circular to oval in outline, scattered, 0.5–1.0 mm. wide by 0.5–1.5 mm. long, brownish black; fructification compound; asci cylindrical, 9–12 by 60–80  $\mu$ ; 8 ascospores, broadly ellipsoid, 6.5–7.5 by 10–12  $\mu$ , uniseriate; spermatia (?) curved or cylindrical, 0.5–1.0 by 15–20  $\mu$ .

On Poaceae:

*Paspalum candidum* (H. & B.) Kunth. Costa Rica.

TYPE LOCALITY: Asseri, Costa Rica, on *Paspalum candidum*.

DISTRIBUTION: Costa Rica to South America.

24. PHYLLACHORA PASPALICOLA P. Henn. Hedwigia 48: 106. 1908.

*Phyllachora vaginata* Chardon, Jour. Dept. Agr. Puerto Rico  
16: 172. 1932.

Clypei amphigenous, circular or oval in outline, scattered, 0.1–0.3 mm. wide by 0.2–0.8 mm. long, black, shining; fructification simple or compound with few ascocarps; asci cylindrical, 8–12 by 65–80  $\mu$ ; 8 ascospores, ellipsoid, 4.5–7 by 9–14  $\mu$ , uniseriate; conidia in similar fructifications, fusoid, sometimes curved, 2–3 by 20–30  $\mu$ , mostly two-celled, hyaline.

On Poaceae:

*Digitaria horizontalis* Willd. Puerto Rico.

*Paspalum conjugatum* Berg. Costa Rica; Cuba; Puerto Rico.

*Paspalum distichum* L. Dominican Republic.

*Paspalum plicatulum* Michx. Canal Zone; Panama.

*Paspalum Saugetii* Chase. Dominican Republic.

*Paspalum tenellum* Willd. Panama.

*Paspalum vaginatum* Sw. Dominican Republic.

*Paspalum* sp. Florida.

TYPE LOCALITY: Para, Brazil, on *Paspalum* sp.

DISTRIBUTION: Central and South America, West Indies.

25. *PHYLLACHORA INSULARIS* Chardon, Jour. Dept. Agr. Puerto Rico 13: 13. 1929.

Clypei amphigenous but more conspicuous on upper leaf surface, scattered, margin indefinite, irregular in outline, 0.1–0.5 mm. wide by 0.2–1.6 mm. long, black; fructification compound with numerous ascocarps; asci cylindrical, 8–12 by 60–85  $\mu$ ; 8 ascospores, broadly ellipsoid, 4.5–6 by 8–11  $\mu$ , uniseriate; conidia in similar fructifications, lunate, 3–3.6 by 26–29  $\mu$ , one-celled, hyaline.

On Poaceae:

*Trichachne insularis* (L.) Nees (*Valota insularis* Chase).  
Cuba; Dominican Republic; Grenada; Puerto Rico; St. Thomas, Jamaica.

*Trichachne patens* Swallen. Texas.

TYPE LOCALITY: Barceloneta, Puerto Rico, on *Valota insularis*.

DISTRIBUTION: South America and West Indies.

EXSICCATI: Ciferri, Myc. Doming. 214.

26. *Phyllachora Leersiae* Chardon, Jour. Dept. Agr. Puerto Rico 16: 176. 1932.

Clypei amphigenous, scattered or in groups, circular in outline, 0.2–0.5 mm. across, black; fructification simple; asci cylindrical-clavate, fragile, 14–18 by 55–75  $\mu$ ; 8 ascospores, narrowly ellipsoid, 7.0–8.5 by 16–21  $\mu$ , biseriate.

On Poaceae:

*Leersia* (*monandra* Sw.). Dominican Republic.

TYPE LOCALITY: Road to San Jose de las Matas, Prov. Santiago.

DISTRIBUTION: Known only from Dominican Republic.

27. *Phyllachora Phalaridis* sp. nov.

Clypei amphigenous but more conspicuous on upper leaf surface, scattered, ellipsoid to fusiform in outline, 0.2–0.5 mm. wide by 0.3–1.0 mm. long, shiny black; fructification simple or compound with few ascocarps; asci cylindrical, 7.5–9 by 70–80  $\mu$ ; 8 ascospores, broadly ellipsoid, 4–5 by 7.5–10  $\mu$ , uniseriate.

On Poaceae:

*Phalaris arundinacea* L. Massachusetts.

TYPE LOCALITY: Southwick, Massachusetts, on *Phalaris arundinacea*. (Seymour 250)

DISTRIBUTION: Known only from type locality.

28. *Phyllachora Ammophilae* sp. nov.

Clypei amphigenous but more conspicuous on upper leaf surface, scattered, linear, 0.2–1.0 mm. wide by 1.0–5.0 mm. long, brownish black; fructification compound with numerous ascocarps; asci cylindrical 10–15 by 90–115  $\mu$ ; 8 ascospores, broadly ellipsoid, 7–9 by 10–15  $\mu$ , often appearing subspherical, uniseriate.

On Poaceae:

*Ammophila arenaria* (L.) Link. Massachusetts, New Jersey, New York.

TYPE LOCALITY: Southhampton, New York, on *Ammophila arenaria*. (Orton, June 27, 1919)

DISTRIBUTION: Long Island, Massachusetts and New Jersey.

29. *Phyllachora Epicampis* sp. nov.

Clypei amphigenous but more conspicuous on upper leaf surface, scattered or gregarious, elliptical to linear in outline, 0.2–1.0 mm. wide by 1.0–3.0 mm. long, dull black, or grayish, often

confluent to form patches up to 2 cm. long; fructification compound with numerous ascocarps; asci cylindrical to clavate, 10–14 by 95–150  $\mu$ , with long pedicels; 8 ascospores, ovate-acuminate, 6–8 by 19–23  $\mu$ , uniseriate or biseriate.

On Poaceae:

*Muhlenbergia rigens* (Benth.) Hitchc. (*Epicampes rigens* Benth.). Arizona, California.

TYPE LOCALITY: Monrovia, California, on *Epicampes rigens*.

DISTRIBUTION: Arizona and California.

30. PHYLLACHORA VULGATA Theissen & Sydow, Ann. Myc. 13: 450. 1915.

*Sphaeria graminis cinerascens* Schw. Trans. Am. Phil. Soc. II. 4: 208. 1832.

*Sphaeria Agrostidis* Schw. Trans. Am. Phil. Soc. II. 4: 210. 1832.

Clypei amphigenous, scattered, oval to ellipsoid in outline, 0.1–1.0 mm. wide by 0.2–2.0 mm. long, dull black; fructification simple or compound, generally with few ascocarps; asci cylindrical, 7–11 by 65–110  $\mu$ ; ascospores ellipsoid, 4–5.5 by 9–12  $\mu$ , uniseriate.

On Poaceae:

*Blepharoneuron tricholepsis* (Torr.) Nash. New Mexico.

*Muhlenbergia asperifolia* (Nees & Mey.) Parodi (*Sporobolus asperifolius* Nees & Mey.). Colorado, Nebraska, New Mexico, North Dakota; British Columbia.

*Muhlenbergia californica* Vas. California.

*Muhlenbergia cuspidata* (Torr.) Rydb. (*Sporobolus cuspidatus* Wood. *S. brevifolius* (Nutt.) Scribn. *Vilfa cuspidata* Torr.). Indiana, Iowa, Minnesota, North Dakota, South Dakota, Wyoming.

*Muhlenbergia foliosa* (Roem. & Schult.) Trin. (*Agrostis filiformis* Willd.). Pennsylvania, Wisconsin.

*Muhlenbergia mexicana* (L.) Trin. Illinois, Indiana, Iowa, Maryland, Michigan, Nebraska, New York, Ohio, Pennsylvania, South Dakota, West Virginia; Ontario.

*Muhlenbergia montana* (Nutt.) Hitchc. (*M. gracilis* Auct.). Colorado.

*Muhlenbergia Porteri* Scribn. Arizona.



*Muhlenbergia racemosa* (Michx.) B.S.P. (*M. glomerata* Trin.). Colorado, Georgia, Illinois, Kansas, Michigan, Nebraska, New York, North Dakota, South Dakota, Wisconsin; Ontario.

*Muhlenbergia Reverchoni* Vasey & Scribn. Maryland.

*Muhlenbergia Schreberi* Gmel. (*M. diffusa* Willd.). Georgia, Illinois, Iowa, Louisiana, Maryland, Mississippi, New York, North Dakota, Pennsylvania, Tennessee, West Virginia.

*Muhlenbergia sobolifera* (Muhl.) Trin. Iowa, Pennsylvania.

*Muhlenbergia spiciformis* Trin. Jalisco.

*Muhlenbergia squarrosa* (Trin.) Rydb. New Mexico, North Dakota.

*Muhlenbergia sylvatica* Torr. Kansas, Maine, Missouri, Wisconsin.

*Muhlenbergia tenuiflora* (Willd.) B.S.P. Wisconsin.

*Muhlenbergia uniflora* (Muhl.) Fernald (*Sporobolus serotinus* A. Gray, *S. uniflorus* Scribn. & Merr.). Vermont.

*Muhlenbergia* sp. Alabama, Rhode Island.

*Sporobolus airoides* (Torr.) Torr. Colorado.

*Sporobolus argutus* (Nees) Kunth. Texas.

*Sporobolus asper* (Michx.) Kunth. Illinois.

*Sporobolus cryptandrus* (Torr.) A. Gray. Kansas, Texas.

*Sporobolus* sp. South Dakota.

TYPE LOCALITY: Saline River, Kansas, on *Muhlenbergia sylvatica*.

DISTRIBUTION: Southern Canada, United States, and in Mexico.

EXSICCATI: Barth. Fungi Columb. 2249, 2342, 2443, 3733, 3923; Brenckle, Fungi Dak. 8, 9; Ellis & Ev. Fungi Columb. 525; Griff. W. Am. Fungi 4.

### 31. *Phyllachora texensis* sp. nov.

Clypei amphigenous, scattered or sometimes gregarious, elliptical to fusiform in outline, 0.2–0.4 mm. wide by 1.0–1.5 mm. long, dull black; fructification compound with numerous ascarps; asci cylindrical, 7–11 by 100–120  $\mu$ , pedicels long; 8 ascospores, narrowly ellipsoid, 6.5–7.5 by 13–16  $\mu$ , uniseriate.

On Poaceae:

*Muhlenbergia Reverchoni* Vasey & Scribn. Texas.



TYPE LOCALITY: Fort Worth, Texas, on *Muhlenbergia Reverchoni*. (Reverchon 3539)

DISTRIBUTION: Known only from type locality.

32. *Phyllachora coloradensis* sp. nov.

Clypei amphigenous, scattered or gregarious, ellipsoid to linear in outline, 0.2–0.5 mm. wide by 0.5–1.5 mm. long, sometimes forming larger groups up to 5 mm. long, dull black; fructification usually compound; asci cylindrical, 9–12 by 70–85  $\mu$ ; 8 ascospores, narrowly ellipsoid, 5.5–6 by 11–14  $\mu$ , uniseriate; conidia present in similar fructifications, fusiform, 5.5–7 by 15–20  $\mu$ , four-celled, hyaline.

On Poaceae:

*Muhlenbergia Montana* (Nutt.) Hitchc. (*M. trifida* Hack.).  
Colorado.

TYPE LOCALITY: Pikes Peak, Colorado, on *Muhlenbergia trifida*.

DISTRIBUTION: Known only from type locality.

33. *Phyllachora Oryzopsidis* (Rehm) Theiss. & Sydow, Ann. Myc. 13: 451. 1915.

*Phyllachora graminis* f. *Oryzopsidis* Rehm, Ascomycetes 1916: (hyponym).

Clypei chiefly epiphyllous, slightly evident on under surface of leaf, scattered, elliptical to short linear in outline, 0.2–0.4 mm. wide by 0.3–1.0 mm. long, black, shiny; fructification compound with numerous ascocarps; asci cylindrical, 9–10 by 70–100  $\mu$ ; 8 ascospores, narrowly ellipsoid, 5–6.5 by 11–14  $\mu$ , uniseriate.

On Poaceae:

*Oryzopsis asperifolia* Michx. Massachusetts, Michigan, New York, Vermont; Ontario, Quebec.

TYPE LOCALITY: London, Ontario, on *Oryzopsis asperifolia*.

DISTRIBUTION: New England west to Michigan and north into Canada.

EXSICCATI: Rehm, Ascom. 1916. Barth. Fungi Columb. 3536.

34. *Phyllachora BOUTELOUAE* Rehm, Hedwigia 36: 373. 1897.

*Phyllachora boutelouicola* Speg. Anal. Mus. Nac. Buenos Aires III. 12: 415. 1909.

*Phyllachora chloridicola* Speg. Anal. Mus. Nac. Buenos Aires III. 12: 416. 1909.

*Phyllachora minima* Chardon, Jour. Dept. Agr. Puerto Rico  
16: 175. 1932.

Clypei amphigenous but more conspicuous on upper leaf surface, oval to elliptical in outline, scattered, sometimes confluent, 0.3–1 mm. wide by 0.5–2.0 mm. long, brownish black; fructification generally compound with few to numerous ascocarps; asci cylindrical, 9–12 by 75–95  $\mu$ , operculum prominent; 8 ascospores, broadly ellipsoid, 5–6 by 8.5–11  $\mu$ , uniseriate.

On Poaceae:

*Bouteloua curtipendula* (Michx.) Torr. Illinois, Texas, Wisconsin.

*Bouteloua gracilis* (H.B.K.) Lag. (*B. oligostachya* Torr.).  
Nebraska, New Mexico, North Dakota, South Dakota.

*Bouteloua heterostega* (Trin.) Griff. Dominican Republic;  
Puerto Rico.

*Bouteloua hirsuta* Lag. Wisconsin.

*Buchloe dactyloides* (Nutt.) Engelm. (*Bulbilis dactyloides*  
Raf.). Arkansas, Kansas, Texas.

*Chloris chloridea* (Presl.) Hitchc. Texas.

*Chloris orthonoton* Doell. Guatemala.

*Chloris submutica* H.B.K. Coahuila.

*Chloris virgata* Sw. Lower California.

TYPE LOCALITY: Argentina on *Bouteloua curtipendula* var.  
*aristosa*.

DISTRIBUTION: Wisconsin to Nebraska, south to Mexico and  
in South America.

35. PHYLLACHORA LEPTOCHLOAE Chardon, Jour. Dept. Agr.  
Puerto Rico 16: 176. 1932.

Clypei amphigenous, oval to elliptical, sometimes linearly extended to produce an irregular outline, scattered, rarely confluent, 0.3–1 mm. wide by 0.7–3 mm. long, black, somewhat shiny; fructification compound with few to numerous ascocarps; asci cylindrical, 9.5–13 by 75–95  $\mu$ ; 8 ascospores, ovate-acuminate or fusiform, 5–6 by 14–19  $\mu$ , chiefly uniseriate; spermatia sinuous, 1.0 by 15–20  $\mu$ , continuous.

On Poaceae:

*Leptochloa virgata* (L.) Beauv. Canal Zone; Honduras.

TYPE LOCALITY: La Fragua, Honduras, on *Leptochloa virgata*.

DISTRIBUTION: Central America to Venezuela.

36. *PHYLLACHORA SERIALIS* Ellis & Ev. Jour. Myc. 8: 18. 1902.

Clypei poorly developed, amphigenous but more conspicuous on under surface of the leaf, elliptical to linear in outline, 0.1–0.2 mm. wide by 0.5–1 mm. long, gregarious, often confluent to form lines up to 5 mm. long; fructification simple or rarely compound; asci cylindrical, 10–15 by 70–80  $\mu$ ; 8 ascospores, ellipsoid, 5–6 by 10–13  $\mu$ , uniseriate.

On Poaceae:

*Elymus triticoides* Buckl. California.

*Spartina leiantha* Benth. California.

TYPE LOCALITY: Pacific Grove, California, on *Spartina stricta*, error for *S. leiantha*.

DISTRIBUTION: Known only from type locality.

37. *Phyllachora Spartinae* sp. nov.

Clypei chiefly epiphyllous, slightly noticeable on under leaf surface, elliptical to linear, 0.5–1.0 mm. wide by 2.0–3.0 mm. long, scattered, grayish to shining black; fructification compound with numerous ascocarps; asci cylindrical to narrowly ellipsoid, 15–20 by 90–110  $\mu$ ; ascospores, broadly ovoid to broadly ellipsoid, often appearing nearly spherical, 9–12 by 15–19  $\mu$ , uniseriate.

On Poaceae:

*Spartina alterniflora* Lois. Florida, Georgia, Maryland.

TYPE LOCALITY: Savannah, Georgia, on *Spartina alterniflora*.

DISTRIBUTION: Along the coast from Maryland to Florida.

38. *Phyllachora Pammelii* sp. nov.

Clypei amphigenous, scattered, elliptical to linear in outline, 0.2–0.6 mm. wide by 0.5–2 mm. long, black, not shining; fructification compound with numerous ascocarps; asci cylindrical, 8–12 by 70–80  $\mu$ ; ascospores fusiform, 4.5–5 by 10–14  $\mu$ , uniguttulate, uniseriate or occasionally biseriate.

On Poaceae:

*Distichlis stricta* (Torr.) Rydb. Colorado.

TYPE LOCALITY: Fort Collins on *Distichlis stricta*.

DISTRIBUTION: Known only from type locality.

39. *PHYLLACHORA DIPLOCARPA* Ellis & Ev. Bull. Torrey Club 24: 292. 1897.

*Phyllachora Nuttalliana* Fairm. in Millsp. & Nutt. Pub. Field Mus. Nat. Hist. 5: 345. 1923.

Clypei hypophyllous chiefly, oval to elliptical in outline, 0.2–0.5 mm. wide by 0.5–1.0 mm. long, more rarely up to 2.0 mm. long, scattered or sometimes confluent to form larger groups, dull black; fructification compound, with few ascocarps, flattened in the scanty mesophyll; asci clavate or somewhat saccate, more rarely cylindrical, 11–14 by 50–60  $\mu$ , often with prominent pedicel; 8 ascospores, narrowly ellipsoid, 4.5–5.5 by 13–17  $\mu$ , uniseriate or partially biseriate, or more generally inordinate.

On Poaceae:

*Distichlis spicata* (L.) Greene (*D. maritima* Raf.). California, Colorado, Kansas, New Mexico, South Dakota, Texas.

*Distichlis stricta* (Torr.) Rydb. California, North Dakota, Texas.

*Spartina patens* (Ait.) Muhl. South Carolina.

TYPE LOCALITY: Rooks County, Kansas, on *Distichlis maritima*.

DISTRIBUTION: On plains from North Dakota to New Mexico and on the Pacific coast, mostly on alkaline soils.

EXSICCATI: Barth. Fungi Columb. 4745; Brenckle, Fungi Dak. 10; Ellis & Ev. Fungi Columb. 955; Ellis & Ev. N. Am. Fungi 3439; Griff. W. Am. Fungi 2.

40. PHYLLACHORA ERAGROSTIDIS Chardon, Bol. Soc. Venez. Cien. Natur. 40: 17 (?). 1939.

Clypei amphigenous, scattered, oval to elliptical in outline, 0.1–0.4 mm. wide by 0.5–1.5 mm. long, sometimes confluent to form wider and longer patches, black; fructification compound with numerous ascocarps; asci cylindrical, 8–10 by 80–100  $\mu$ ; ascospores narrowly ovoid to ellipsoid, 4.5–6 by 10–13  $\mu$ , uniseriate; form on *Triodia flava* with ascospores 4.5–5.0 by 6.0–8.0  $\mu$ .

On Poaceae:

*Eragrostis capillaris* (L.) Nees (*E. tenuis* Steud.). Alabama, Nebraska, Texas.

*Eragrostis hirsuta* (Michx.) Nees. Georgia.

*Eragrostis Palmeri* S. Wats. Texas.

*Eragrostis* sp. New Mexico.

*Triodia albescens* Vasey. Texas.

*Triodia flava* (L.) Smyth (*Tridens flavus* Hitchc.). Georgia, Texas.

TYPE LOCALITY: Miranda, Venezuela, on *Eragrostis polytricha*.

DISTRIBUTION: Georgia to Nebraska and Texas; also in South America.

41. *PHYLLACHORA SILVATICA* Sacc. & Speg. Mich. 1: 410. 1878.

Clypei mostly hypophyllous, scattered or often gregarious, roundish or oval in outline, 0.4–0.8 mm. wide by 0.5–1 mm. long, black; fructification compound with few ascocarps; asci cylindrical or narrowly elliptical, 10–15 by 75–100  $\mu$ ; 8 ascospores, ellipsoid to fusiform or ovoid, 6.0–7.5 by 12–16  $\mu$ , biseriate or uniseriate.

On Poaceae:

*Festuca dertonensis* (All.) Aschers. & Graebn. Oregon.

*Festuca idahoensis* Elmer. California.

*Festuca megalura* Nutt. Oregon.

*Festuca occidentalis* Hook. Oregon.

*Festuca rubra* L. California, Oregon.

TYPE LOCALITY: Northern Italy on *Festuca duriuscula*.

DISTRIBUTION: Northwestern United States and Northern Italy.

42. *PHYLLACHORA GRAMINIS* (Pers.) Fuckel, Symb. Myc. 216. 1869.

*Sphaeria graminis* Pers. Obs. Myc. 18. 1796.

*Phyllachora graminis* *Elymorum* Fries, Syst. Myc. 2: 434. 1823.

*Sphaeria graminis* *Elymorum* Schw. Trans. Am. Phil. Soc. II. 4: 208. 1832.

*Dothidea graminis* Fries, Summa Veg. 387. 1845.

*Phyllachora Bromi* Fuckel, Symb. Myc. 216. 1869.

*Phyllachora Asperellae* Roum. & Fautr. Rev. Myc. 175. 1892. Roum. Fungi Sel. Exs. 6173.

*Phyllachora graminis* f. *Hystricis* Rehm, Ascom. 1917 (hyponym).

*Phyllachora Agrostidis* Orton, House, N. Y. State Mus. Bull. 243–244: 91. 1923 (homonym).

*Phyllachora Elymi* Orton, House, N. Y. State Mus. Bull. 243–244: 92. 1923 (hyponym).

*Phyllachora Melicae* Dearn & House, N. Y. State Mus. Bull. 266–270. 1925.

*Phyllachora Cinnae* Tehon & Dan. *Mycologia* 19: 110. 1927.

Clypei amphigenous, scattered, long elliptical to linear, often fusiform in outline, 0.1–1.0 mm. wide by 0.2–5.0 mm. long, frequently confluent, black; fructification compound with many ascocarps; asci cylindrical, 8–10 by 70–100  $\mu$ ; 8 ascospores, ellipsoid, 4.5–6 by 9–12  $\mu$ , uniseriate.

*Agropyron cristatum* Beauv. Nova Scotia.

*Agropyron pauciflorum* (Schwein.) Hitchc. New York.

*Agropyron repens* (L.) Beauv. Iowa, Maine, Massachusetts, New Hampshire, New York, Pennsylvania, Rhode Island, Vermont, West Virginia, Wisconsin; Alberta, Ontario, Quebec.

*Agrostis alba* L. California, New York, Virginia.

*Brachyletrum erectum* (Schreb.) Beauv. Nebraska, Vermont.

*Bromus ciliatus* L. Indiana, Wisconsin.

*Bromus purgans* L. Pennsylvania.

*Bromus tririi* Desv. California.

*Calamagrostis canadensis* (L.) Beauv. Michigan, Nebraska, New York, Wisconsin.

*Cinna arundinaceae* L. Illinois, Kansas, Maryland, Virginia.

*Elymus canadensis* L. Illinois, Indiana, Iowa, Maryland, Michigan, Minnesota, Mississippi, Nebraska, New York, North Dakota, Ohio, Pennsylvania, South Dakota, Vermont, Virginia, West Virginia, Wisconsin, District of Columbia.

*Elymus canadensis* var. *brachystachys* Farwell. Wisconsin.

*Elymus canadensis* var. *robustus* (Scribn. & Sm.) Mackenz. & Bush. Illinois, Kansas, Minnesota, Vermont; Ontario.

*Elymus condensatus* Presl. California.

*Elymus glaucus* Buckl. California, Montana, New York.

*Elymus riparius* Wieg. New York, Pennsylvania, West Virginia.

*Elymus triticoides* Buckl. California.

*Elymus virginicus* L. (*Elymus striatus* Willd.). Arkansas, Illinois, Indiana, Iowa, Kansas, Kentucky, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Nebraska, New York, Ohio, Pennsylvania, South Dakota, Virginia, West Virginia, Wisconsin, District of Columbia; Ontario.



*Elymus virginicus* var. *australis* (Scribn. & Ball) Hitchc.  
Georgia, Missouri, North Carolina.

*Elymus virginicus* var. *glabriflorus* (Vasey) Bush. Pennsyl-  
vania, West Virginia.

*Elymus virginicus* var. *halophilus* (Bick.) Wieg. Massachu-  
setts.

*Elymus virginicus* var. *intermedius* (Vasey) Bush. Missouri,  
Pennsylvania.

*Elymus virginicus* var. *submuticus* Hook. North Dakota.  
*Festuca elatior* (L.) Chase. Maine.

*Hordeum jubatum* L. Wisconsin.

*Hordeum* sp. California.

*Hystrix patula* Moench (*Hystrix Hystrix* (L.) Millsp.). Illi-  
nois, Indiana, Iowa, Kentucky, Michigan, New Jersey,  
New York, Ohio, Pennsylvania, Vermont, Virginia, West  
Virginia, Wisconsin; Ontario.

*Melica striata* (Michx.) Hitchc. Wisconsin.

*Panicum virgatum* L. Iowa, Kansas, Kentucky, Maryland,  
Nebraska, New York, North Carolina, Rhode Island,  
Wisconsin.

*Pappophorum mucronulatum* Nees. Texas.

*Phleum pratense* L. Maine; Prince Edward Island.

*Triticum aestivum* L. Iowa.

*Uniola laxa* (L.) B.S.P. Georgia.

TYPE LOCALITY: Europe on *Elymus europeus*.

DISTRIBUTION: Around the world, chiefly in North Temperate  
zone.

EXSICCATI: Barth. Fungi Columb. 2947, 3921, 3922; Seym. &  
Earl. Econ. Fungi 395; Kell. Ohio Fungi 50; Ellis & Ev. Fungi  
Columb. 2133, 2134; Ellis & Ev. N. Am. Fungi 2127; Rab. &  
Winter. Fungi Eur. 3061(b); Rehm, Ascom. 1917; Ellis, N. Am.  
Fungi 484; Davis, Fungi Wisc. Exs. 39; Wils. & Seav. Ascom. &  
Lower Fungi 42; N. Dak. Fungi 16; Guba, Fungi of Nantucket  
160, 161.

43. *Phyllachora Arundinariae* sp. nov.

Clypei small, amphigenous, scattered, or sometimes gregarious,  
oval to elliptical in outline, 0.1–0.4 mm. wide by 0.1–0.8 mm.  
long, black; fructification simple or compound with few asco-

carps; asci narrowly ellipsoid, 12–18 by 75–100  $\mu$ ; 8 ascospores fusiform to narrowly ellipsoid, 6–8.5 by 15–20  $\mu$ , biseriate or more rarely uniseriate.

On Poaceae:

*Arthrostylidium angustifolium* Nash. Cuba.

*Arundinaria tecta* (Walt.) Muhl. Alabama, Georgia, South Carolina.

TYPE LOCALITY: Darien, Georgia, on *Arundinaria tecta*.

DISTRIBUTION: Alabama to Georgia and the West Indies.

EXSICCATI: Ravenel, Fungi Am. 389.

44. *Phyllachora excelsior* sp. nov.

Clypei amphigenous, scattered, oval to ellipsoid in outline, 1 mm. wide by 2 mm. long, black, often located on necrotic or chlorotic spots; fructification compound with numerous ascocarps; asci cylindrical or narrowly ellipsoid, 15–25 by 150–180  $\mu$ ; 8 ascospores, ovate-acuminate to fusiform, 9–10 by 30–38  $\mu$ , biseriate or uniseriate.

On Poaceae:

*Arthrostylidium excelsum* Griseb. Guadeloupe.

TYPE LOCALITY: Guadeloupe on *Arthrostylidium excelsum*.

DISTRIBUTION: Known only from type locality.

45. *Phyllachora portoricensis* (Chardon) comb. nov.

*Spaerodothis portoricensis* Chardon, Jour. Dept. Agr. Puerto Rico 16: 189 1932.

*Phyllachora Arthrostylidii* Pet. & Cif. Ann. Myc. 30: 232. 1932.

Clypei amphigenous, scattered, ellipsoid to linear, 0.2–0.7 mm. wide by 0.7–4 mm. long, black; fructification compound with numerous ascocarps; asci clavate, 20–25 by 90–120  $\mu$ ; 8 ascospores narrowly ovoid, 7.5–9.5 by 19–24  $\mu$ , usually biseriate.

On Poaceae:

*Arthrostylidium multispicatum* Pilger. Dominican Republic.

*Arthrostylidium sarmentosum* Pilger. Puerto Rico.

TYPE LOCALITY: Loquillo Mts., Puerto Rico, on *Arthrostylidium sarmentosum*.

DISTRIBUTION: Known only from the West Indies.

46. *PHYLLACHORA TETRASPORA* Chardon, Jour. Dept. Agr. Puerto Rico 16: 178. 1932.



Clypei chiefly epiphyllous, scattered, linear, 0.5–1.0 mm. wide by 2.5 mm. long, black; fructification compound; asci clavate, 12–14 by 60–85  $\mu$ ; 4 ascospores, irregularly arranged, narrowly ellipsoid, 6–7.5 by 18–22  $\mu$ ; wall rather thick.

On Poaceae:

*Bambos vulgaris* Schrad. Dominican Republic.

TYPE LOCALITY: Santiago, Dominican Republic, on *Bambusa vulgaris*.

DISTRIBUTION: West Indies and South America.

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## ADDITIONS TO THE UREDINALES OF VENEZUELA—III <sup>1</sup>

FRANK D. KERN AND H. W. THURSTON, JR.

Previous lists of Venezuelan Uredinales are as follows:

SYDOW, H. Fungi venezuelani [Uredinales]. Ann. Myc. 28: 37-52. 1930.

KERN, THURSTON & WHETZEL. Uredinales in Mycological Explorations of Venezuela. Monog. Univ. Puerto Rico B. 2: 262-303. 1934.

KERN, FRANK D. Additions to the Uredinales of Venezuela. Mycologia 30: 537-552. 1938.

KERN & THURSTON. Additions to the Uredinales of Venezuela—II. Mycologia 35: 434-445. 1943.

The total number of species reported in the foregoing lists is 238. We are now adding 25 species, bringing the total up to 263 species belonging to 31 genera. For notes concerning the collectors who have made possible these additions see KERN & THURSTON (l.c.), pp. 434-435. In the following list we are including notes about four species previously reported; these species which do not represent new records for Venezuela are marked with an asterisk.

For the determination of certain host plants we are indebted to Dr. E. P. Killip, Smithsonian Institution, Dr. H. A. Gleason, New York Botanical Garden, and Dr. R. E. Woodson, Jr., Missouri Botanical Garden; for aid in the preparation of the Latin diagnoses we are indebted to Dr. R. E. Dengler, The Pennsylvania State College.

AECIDIUM JACQUEMONTIAE Ellis & Ev. Jour. Myc. 8: 11. 1902.

On *Jacquemontia lactescens* Seem. Road Maracay a Guigue, Est. Aragua, March 31, 1939, Chardon, Whetzel & Müller 3254.

<sup>1</sup> Contribution from the Department of Botany, The Pennsylvania State College, No. 139. Publication authorized August 30, 1943, as paper No. 1191 in the Journal Series of the Pennsylvania Agricultural Experiment Station.

This rust has been reported previously from Yucatan and Panama. In N. Am. Flora 7: 634, 1924, Arthur uses the name *Thyella hirtiflora* (Mart. & Gall.) House for the host here listed.

ANGIOPSORA ZEAЕ Mains, Mycologia 30: 42. 1938.

On *Zea Mays* L. Gardens, Central Lucinda, Est. Carabobo, April 13, 1938, C. E. Chardon 2590; Hacienda Bramon, Est. Tachira, May 10, 1934, Kern & Toro 1812.

The pale yellow uredinia, the colorless or pale uredospores, and the covered telia with teliospores in catenulate rows are characteristics of this rust. For many years it was recognized that there was a rust of corn in southern and tropical regions which was distinct from the common rust of the temperate zone, *Puccinia Sorghi*. This rust has been called *Puccinia pallescens*. It is now believed that *P. pallescens* occurs only on *Tripsacum*. It is also an *Angiopsora* and not a *Puccinia*. The uredospores of *Angiopsora pallescens* are smaller than those of the corn rust and the telia differ in several important respects. These facts led Mains to propose the name *Angiopsora Zeae*. Teliospores on corn are apparently rather rare. They are present on our specimen No. 2590.

Mains reports *A. Zeae* from Guatemala, Puerto Rico, and Trinidad. In addition to these Venezuelan specimens we have specimens from the Dominican Republic and Colombia.

ARTHURIA COLUMBIANA (Kern & Whet.) Cummins, Bull. Torrey Club 70: 519. 1943.

*Phakopsora columbiana* Kern & Whet. Jour. Dept. Agr. Puerto Rico 14: 304. 1930.

On *Croton* sp. Taquara, Dist. Federal, Feb. 12, 1939, F. Tamayo 2381.

This species is otherwise known only from the type locality in Colombia. Dr. Cummins has discovered that the uredospores are catenulate and not stalked and has made the transfer to the genus *Arthuria*.

CHRYSOCYCLUS MIKANIAE (Arth.) Sydow, Ann. Myc. 23: 324. 1925.

On *Mikania* sp. Road Maracay a Choroni, Est. Aragua, March 26, 1939, *Chardon & Whetzel* 3168.

Previous reports of this species are from Brazil and Bolivia.

DASYSPORA GREGARIA (Kunze) P. Henn. *Hedwigia* **35**: 320. 1896.

On *Xylopia* sp. Road Maracay a Guigue, Est. Aragua, March 31, 1939, *Chardon, Whetzel & Müller* 3250.

This interesting species is often called *Dasyspora foveolata* Berk. & Curt. Mains (Carnegie Inst. Wash. Publ. No. **461**: 103-104, 1935) has discussed the nomenclature and illustrated the spore-stages. Our specimen has only teliospores. They are *Puccinia*-like with filiform appendages at each end. The uredinal stage is hyphomycete-like with spores borne on branched multicellular hyphae which protrude from the stomata. It is the uredinal stage which precludes the rust from belonging to the genus *Puccinia*. *Dasyspora* is a monotypic genus; it is now known from British Honduras, Costa Rica, Panama, Brazil, Surinam (type locality), and Venezuela.

PHAKOPSORA AESCHYNOMENIS Arth. Bull. Torrey Club **44**: 509. 1917.

On *Aeschynomene americana* L. Caracas, Dist. Federal, June 26, 1938, *A. S. Müller* 2186.

This rust is widely distributed in the West Indies and in Mexico. The only other record known to us from South America is that of Mayor in Colombia (Mem. Soc. Neuch. Sci. Nat. **5**: 586-587, 1913).

\*PHAKOPSORA CHERIMOLIAE (Lagerh.) Cummins, Bull. Torrey Club **68**: 467. 1941.

*Uredo Cherimoliae* Lagerh. Bull. Soc. Myc. Fr. **11**: 215. 1895.

*Physopella Cherimoliae* Arth. Résult. Sci. Congr. Bot. Vienne **338**. 1906.

Dr. Cummins working with a specimen from Guatemala has found teliospores so that the reference to the genus *Phakopsora* is possible. The rust occurs in tropical regions of the Americas from Florida to Ecuador. This change of name affects the

following specimens previously reported as *Uredo Cherimoliae*: Chardon, Toro & Alamo 165, 313; Sydow 307.

PHAKOPSORA CROTALARIAE (Diet.) Arth. Bull. Torrey Club 44: 509. 1917.

On *Crotalaria anagyroides* H.B.K. Forests at Los Venados, above Caracas, Dist. Federal, July 8, 1938, C. E. Chardon 2702; Petare a Santa Lucia, Est. Miranda, April 13, 1939, Whetzel & Müller 3078.

Previously known only from Brazil.

PUCCINIA DEFORMATA Berk. & Curt.; Berk. Jour. Linn. Soc. 10: 357. 1869.

On *Olyra latifolia* L. Hacienda Lucinda, Urama, Est. Carabobo, April 2, 1939, Chardon, Whetzel & Müller 3283.

Originally from Cuba, this interesting species is known also from Jamaica, Puerto Rico, Nicaragua and Trinidad.

PUCCINIA FALLAX Arth.; Mains, Carnegie Inst. Wash. No. 461: 103. 1935.

*Puccinia fallaciosa* Arth. Mycologia 9: 84. 1917. Not *P. fallaciosa* Thüm.

On *Palicourea petiolaris* H.B.K. Road Petare a Santa Lucia, Est. Miranda, April 13, 1939, Whetzel & Müller 3397.

Heretofore reported from Puerto Rico and the Dominican Republic.

PUCCINIA INVAGINATA Arth. & Johnston, Mem. Torrey Club 17: 146. 1918.

On *Gouania polygama* (Jacq.) Urban. Jaguará, Caracas, Dist. Federal, Feb. 15, 1939, F. Tamayo 3075; Tucupe, near Caracas, Dist. Federal, Feb. 28, 1939, Whetzel & Müller 2849.

This rust is known from the West Indies, Guatemala, and Brazil. Both of these specimens have well developed telia.

PUCCINIA RUBRICANS Holway, Jour. Myc. 10: 165. 1904.

On *Banisteria cornifolia* (Kunth) Spreng. Hacienda Lucinda, Urama, Est. Carabobo, April 3, 1939, Chardon, Whetzel & Müller 3312.



Our specimen has only secondary uredinia. There are known in the life cycle pycnia, primary and secondary uredinia, and telia. The secondary uredospores have very thick walls (4-7  $\mu$ ) which show a more or less colorless outer layer. The spines are large, sparse, and sharp. The species was originally described from Brazil and has been reported from southwestern Mexico.

*PUCCINIA UNILATERALIS* (Arth.) Cummins, Bull. Torrey Club **67**: 67. 1940.

On *Geranium velutinum* Turcz. Paramo de la Negra, Est. Tachira, Nov. 13, 1939, *Barrus & Müller* 3596.

An interesting species. Our specimen has the typical uredospores with the reniform shape and one pore on the concave side. It has been reported from Mexico, Colombia, and Ecuador.

\**Puccinia venezuelana* (Kern, Thurston & Whetzel) comb. nov.

*Uredo venezuelana* Kern, Thurston & Whetzel, Monog. Univ. Puerto Rico B. **2**: 297. 1934.

In the account of the Uredinales in "Mycological Explorations of Venezuela" (l.c.) *Uredo venezuelana* was described as a new species on *Euphorbia crotonifolia* from La Mesa, Est. Trujillo.

We now have a collection on *Euphorbia caracasana* Muell. from Quebrada de Duri, Est. Trujillo, collected Nov. 11, 1939, by *Barrus & Müller* 3607, which has both uredinial and telial stages. The uredospores of this collection are so similar to those of the type of *Uredo venezuelana* there can be no doubt that they belong here. In the original description there is no statement that the wall of the uredospores consists of two layers. In both collections, however, there are some spores in which this is evident. The pores were said to be apparently 8, in two transverse zones equidistant from the equator. It should be added that they are sometimes so irregular as to appear scattered but there is a tendency toward the zonal arrangement.

A description of the telial stage follows:

Telia amphigenous, similar to uredinia in size and distribution, early naked, dark chocolate-brown; teliospores ellipsoid or oblong-ellipsoid, 21-26  $\times$  58-71  $\mu$ , rostriform at apex, rounded below, not or only slightly constricted at the septum; wall dark chestnut-

brown, 3.5–4  $\mu$  thick, with a golden-brown rostriform umbo, 16–19  $\mu$ , closely and finely verrucose; pedicel colorless below, often golden-brown and enlarged next to spore, usually 7–9  $\mu$  in diam., sometimes wider at base, about once length of spore.

It is interesting to note that this species has several characteristics in common with other species on *Euphorbia* (*Aklema*) such as *Puccinia Euphorbiae longipes* Sydow, *Puccinia velata* (Ellis & Ev.) Arth., and *Puccinia festata* Jacks. & Holw. In all of these the teliospores are rostriform at the apex, the wall is chestnut-brown and verrucose, and the pedicels are colorless except next to the spore where they are tinted and somewhat enlarged. There are differences, however, in size of both teliospores and uredospores, in the presence or absence of bulbous swellings at the bases of the teliospore pedicels, and other combinations of characters, which make all of them valid species.

***Puccinia Waltheriae* sp. nov.**

Teleutosoris hypophyllis vel cauliculis, sparsis vel gregibus 2–3 mm. diam. in maculis decoloratis insidentibus, rotundatis vel ovatis, 0.1–0.5 mm. diam., pulvinatis, compactis, mox nudis, primum pallide cinnamomeo-brunneis, dein germinando cinerascens; epidermide rupta non visibile; teleutosporis ellipsoideis, 16–23  $\times$  51–64  $\mu$ , supra attenuatis et infra rotundatis, non vel leniter ad septum constrictis; tunica pallide aurato-brunnea, 2–2.5  $\mu$  cr., supra incrassata ad 6–8  $\mu$ , levi; pedicello hyalino, 6–8  $\mu$  lato, 65–112  $\mu$  longo.

On *Waltheria americana* L. La Guaira-Caracas road, Dist. Federal, March 3, 1939, Müller & Whetzel 2910.

This is a microcyclic species. Rusts are not at all common on the family Sterculiaceae. There is a microcyclic form on species of *Buettneria* in Central America but the teliospores are much smaller and the walls are thinner than in our species. Both the habit and the spores of our species are very like those of *Puccinia Malvacearum*. As that species inhabits the family Malvaceae we do not believe that the species on a genus of the Sterculiaceae can be identical even though similar.

RAVENELIA CAULICOLA Arth. N. Am. Flora 7: 143. 1907.

On *Cracca* (*Tephrosia*) sp. Near Los Teques, Est. Miranda, Feb. 5, 1935, W. A. Archer H261.

This species was originally described from the Bahama Islands.

It has also been reported from the Dominican Republic and Puerto Rico.

*RAVENELIA CUBENSIS* Arth. Mem. Torrey Club 17: 118. 1918.

On *Peirania* *Saeri* Britton & Rose. Quibor, Est. Lara, Nov. 24, 1939, *Barrus & Müller* 3593.

This species is known only in the uredinal stage and up to the present we find it known only from the type collection. Our specimen agrees perfectly with the type specimen as regards both habit and spore characters. There are no paraphyses, the spore walls are thicker above and the pores are 4, equatorial. We have had the opportunity to study the type through the aid of Dr. G. B. Cummins.

We are informed that the host here listed as *Peirania* is a segregate from the genus *Cassia* but that the transfer of this species to *Cassia* has never been made. We should add that *Cassia biflora* previously reported (Monog. Univ. Puerto Rico, Ser. 2: 292, 1934) as bearing *Ravenelia spinulosa* Diet. & Holw. also belongs to the segregate *Peirania*.

***Ravenelia mirandensis* sp. nov.**

Uredosoris plerumque hypophyllis, sparsis vel in greges parvos dispositis, rotundatis, 0.2–0.5 mm. diam., pallide cinnamomeo-brunneis; epidermide rupta visibile; paraphysibus nullis; uredosporis late ellipsoideis vel obovoideis,  $13\text{--}16 \times 18\text{--}21 \mu$ ; tunica flavida vel pallide aurato-brunnea,  $1 \mu$  cr., minute echinulata; poris 6–8, sparsis.

Teleutosoris amphigenis, sparsis vel in greges 0.2–0.8 mm. diam. dispositis, subepidermalibus, nitide atro-brunneis; epidermide rupta visibile; paraphysibus nullis; capitulis teleutosporarum convexis, obscure castaneo-brunneis,  $42\text{--}58 \mu$  diam., ex sporis 4–5 in omni directione compositis; sporis unicellularibus,  $16\text{--}19 \mu$  diam., papillis (4–6) subhyalinis  $3\text{--}5 \mu$  longis; tunica castaneo-brunnea,  $1.5 \mu$  cr., ad apicem usque  $3 \mu$ ; cystidiis eiusdem numeri atque cellularibus marginalibus, ad capitulum adpressis; pedicello fragili, hyalino, deciduo.

On *Cassia Tora* L. Road Petare-Guarenas, Est. Miranda, March 15, 1939, *Whetzel & Müller* 2967.

The numerous spines on each teliospore and the appressed cysts differentiate this species from the others known on *Cassia* except *R. antiquana* Cummins. From the latter it differs in the lack of paraphyses, the smaller uredospores, and the smaller telial heads which are composed of fewer spores.

RAVENELIA PORTORICENSIS Arth. Bull. Torrey Club 31: 5. 1904.

On *Cassia emarginata* L. Road Caracas to Ocumare del Tuy, Est. Miranda, March 11, 1939, Whetzel & Müller 2979.

Previously reported from the West Indies, Cuba, Jamaica, Haiti, and the Dominican Republic.

\*UREDIO COCCOLOBAE P. Henn. Hedwigia 35: 353. 1896.

On *Triplaris* sp. Experiment Station Grounds, El Valle, Caracas, Dist. Federal, March 17, 1939, G. Vivas Berthier 2993.

The type of *U. Coccolobae* was from Brazil on *Coccoloba populifolia*. Arthur (Mycologia 9: 89, 1917, and N. Am. Flora 7: 609, 1924) took up this name for the West Indian rust on *Coccoloba uvifera*. As explained in the note under *Uredo uviferae* we think this was an incorrect use of the name. We believe the rust on *Coccoloba uvifera* in both the West Indies and Venezuela should be referred to *Uredo uviferae*.

The name *Uredo Coccolobae* used in the Venezuelan list (Monog. Univ. Puerto Rico B. 2: 293) remains in the list as we are now referring to it the rust on *Triplaris*. The genus *Triplaris* is botanically closely related to *Coccoloba*. The spores and paraphyses of our specimen on *Triplaris* agree so closely with *Uredo Coccolobae* that we do not hesitate to suggest this.

Both *Uredo Coccolobae* and *U. uviferae* will perhaps be found to belong to the genus *Phakopsora*. See also *Uredo uviferae*.

#### **Uredo Combreti** sp. nov.

Uredosoris plerumque hypophyllis, sparsis vel in greges parvos dispositis, rotundatis, parvis, 0.1–0.2 mm. diam., mox nudis, pulverulentis, obscure cinnamomeo-brunneis; epidermide rupta inconspicua; uredosporis ellipsoideis, obovoideis, vel reniformibus, saepe irregularibus vel angularibus, 18–23 × 26–35  $\mu$ ; tunica flavida vel cinnamomeo-brunnea, tenui, 1–1.5  $\mu$ , validis echinulatis moderate distributis; poris obscuris.

On *Combretum fruticosum* (Loefl.) Stuntz. Road beyond Ortiz, entrance to Llanos, April 7, 1939, Whetzel, Müller & Chardon 3354.

The host is a shrub of the family Combretaceae. Two species of *Uredo* (*U. longaensis* P. Henn. Bot. Ergeb. Kun.-Sam.-Exped. 159, 1903; *U. terminaliae* P. Henn. Hedwigia 34: 321, 1895) have been described on this family—one from Brazil and one from

Africa. Our species does not agree with either of these in spore characters.

UREDIO CYATHULAE Mayor, Mem. Soc. Neuch. Sci. Nat. 5: 584. 1913.

On *Cyathula achyranthoides* (H.B.K.) Moq. Rancho Grande, road Maracay a Ocumare de la Costa, Est. Aragua, March 28, 1939, Chardon & Whetzel 3186.

Originally described from Colombia this species has been reported also from Panama (N. Am. Flora 7: 609-610, 1924). It has been rarely collected.

UREDIO FICINA Juel, Bih. Sv. Vet.-Akad. Handl. 23 (3)<sup>10</sup>: 25. 1897.

On *Ficus* sp. Saltanejas, Est. Miranda, Nov. 19, 1940, A. S. Müller 3938; Caracas, Dist. Federal, Feb. 18, 1939, F. Tamayo 2392, March 12, 1939, J. Camero-Zamora 2988; San Antonio de los Altos, Est. Miranda, Dec. 8, 1939, Barrus & Müller 3745; Barrancas, Jan. 10, 1940, F. Tamayo 3790.

Sydow reported *Physopella ficina* on *Ficus turbinata* from Venezuela in 1930 (Ann. Myc. 38: 50). In the Kern, Whetzel, and Thurston paper (Monog. Univ. Puerto Rico B. 2: 266, 1934) the Sydow specimen was listed as *Cerotelium Fici* (Cast.) Arth.; we are now agreed that was an error. Subsequent studies lead us to the conclusion that there are two species on *Ficus*. Cummins reached the same conclusion (see Bull. Torrey Club 70: 79, 1943). *Cerotelium Fici* is retained as the name for the rust on the common fig (*Ficus carica*) which has deeply lobed deciduous leaves (Chardon & Toro 636; Chardon 1160; L. Martorell 1577; P. Gonzales 1578). *Uredo ficina* is taken up as the name for the other species. The latter appears to be on those species of *Ficus* which have entire or toothed leaves which are not deciduous. *Uredo ficina* has larger, more strongly echinulate spores. Arthur (N. Am. Flora 7: 103, 1907) kept these two species separate but united them later (N. Am. Flora 7: 697, 1925).

\*UREDIO MACULANS Pat. & Gaill. Bull. Soc. Myc. Fr. 4: 98. 1888.

On *Alternanthera lanceolata* (Benth.) Standl. El Valle, Caracas, Dist. Federal. Nov. 27, 1939, A. S. Müller 3538.

This is one of the first rusts reported from Venezuela. In the original description the type locality was Caracas and the host was given merely as *Amaranthaceae*. Our specimen is from the type locality and the spores agree so well with the description that we have no doubt about our specimen belonging here. We believe this to be the second collection of the species from Venezuela.

Jackson (*Mycologia* 19: 57-58, 1927) reports *Puccinia Mogiphanis* (Juel.) Arth. from Brazil, Bolivia, and Ecuador on several species of *Alternanthera* and on *Achyranthes* sp. The uredospores of this species are larger, thicker-walled, and more coarsely verrucose. We believe this species to be quite distinct from *Uredo maculans*.

Arthur reports *Uredo maculans* from Costa Rica and Panama (*N. Am. Flora* 7: 610, 1924).

***Uredo Monochaeti* sp. nov.**

Uredosoris hypophyllis, sparsis vel in maculis decoloratis aggregatis, rotundatis, 0.1-0.4 mm. diam., pallide cinnamomeo-brunneis, pulverulentis; epidermide rupta visibile; uredosporis late obovoideis, uno latere plerumque applanato vel concavo,  $16-21 \times 23-29 \mu$ ; tunica pallide cinnamomeo-brunnea,  $1-1.5 \mu$  cr., minute crebreque verrucoso-echinulata; poris 2, super-aequatorialibus, plus minusve obscuris.

On *Monochaetum hirtum* (Karst.) Triana. Caracas a Colonia Tovar, Dist. Federal, March 17, 1939, Whetzel & Müller 3901.

There are two rusts on the family Melastomaceae, one species of *Puccinia* and one of *Puccinosira*. Neither of these has a uredo stage. We have found nothing with which to compare our specimen.

UREDIO UVIFERAE Sydow, Monog. Ured. 4: 497. 1924.

On *Coccoloba uvifera* (L.) Jacq. El Valle, Caracas, Dist. Federal, Nov. 27, 1940, J. Camera Zamora 3945.

We have restudied also the specimen Chardon, Toro & Alamo 283 on *Coccolobis uvifera* and believe that it was erroneously reported as *Uredo Coccolobae* P. Henn. (*Monog. Univ. Puerto Rico B.* 2: 293. 1934). Sydow described the rust on *C. uvifera* from Puerto Rico and Cuba as *Uredo uviferae* and called attention to the fact that the spores are larger and thicker walled than

in *U. Coccolobae*—the measurements are  $19-27 \times 29-42 \mu$ , wall  $1.5-2 \mu$ , as against  $14-18 \times 18-28 \mu$ , wall about  $1 \mu$ . So far as we know this is the first time this name has been used for South American specimens. See also *Uredo Coccolobae*.

UROMYCES COLOGANIAE Arth. Bot. Gaz. 39: 387. 1905.

On *Teramnus uncinatus* (L.) Sw. Road Petare to Santa Lucia, Est. Miranda, April 13, 1939, Whetzel & Müller 3402. Heretofore known from Mexico, Guatemala, and Puerto Rico.

UROMYCES DOLICHOSPORUS Diet. & Holw.; Holway, Bot. Gaz. 31: 327. 1901.

On *Tournefortia volubilis* L. Mamo, Dist. Federal, April 9, 1939, F. Tamayo 3082.

Known also from Costa Rica, Mexico, Cuba, Puerto Rico, and Brazil.

UROMYCES HELLERIANUS Arth. Bull. Torrey Club 31: 2. 1904.

On *Melothria* aff. *guadalupensis* (Spreng.) Cogn. Central Lucinda, Est. Carabobo, April 13, 1938, C. E. Chardon 2603.

Known also from Central America, the West Indies, and Ecuador.

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## NOTES ON TAXONOMY AND NOMENCLATURE OF THE POLYPORES

ROLF SINGER

Together with A. A. Bondarzew, the writer has tried to work out a more natural classification of the Polyporaceae which was to be published in 1941 (*Sovietskaya Botanika*, June 1941; however, copies of this and other recent issues of this periodical were not available in Cambridge). The essential part of this system of classification has been published in *Annales Mycologici* **39**: 43-65, 1941, shortly before the war started. Under these circumstances, few mycologists in this Hemisphere have been able to compare our scheme with older classifications. Incidentally, in this country, a parallel effort—though dealing mostly with questions of nomenclature—has been made by Wm. Bridge Cooke (*A nomenclatorial survey of the genera of pore fungi*, *Lloydia* **3**: 81-104, June 1940). Also D. P. Rogers published some important observations on the Corticiineae as well as an essay on the nomenclatorial status of S. F. Gray in mycology (Rogers, Donald P., *Relative dates of S. F. Gray's Natural Arrangement and Fries' Systema*, *Mycologia* **33**: 568-570, 1941), showing that Gray's book is to be considered post-Friesian. Both papers are bound to influence the nomenclature used in our own publications, but appeared too late to come to our attention in time.

It seems, therefore, advisable to give a short extract of our classification in which certain corrections have been made as far as they have become necessary on the base of the data published by Cooke and Rogers.

A short Latin description will be added to the name of each genus proposed, as far as it is new; for the rest of the genera, the type species only is indicated. The numbers in parentheses after a generic name refer to notes concerning this particular genus, given under the headline "Diagnoses and Observations."

The classification is based on the following subfamilies and genera.



A. Subfamily POROIDEAE: **Fibuloporia** B.-S.<sup>1</sup> (1); **Xylodon** Karst. non Ehrenb., type *X. paradoxus* (Schräd.) Karst.; **Podoporia** Karst. *sensu* Donk, type *P. sanguinolenta* (Alb. & Schw.) Hoehn.; **Ceraporus** Donk, type *C. viridans* (Berk. & Br.) Donk; **Amyloporia** B.-S. (2); **Aporpium** B.-S. (3); **Chaetoporellus** B.-S. (4); **Chaetoporus** Karst., type *C. euporus* (Karst.) B.-S.

B. Subfamily TYROMYCETOIDEAE: **Laetiporus** Murr., type *L. sulphureus* (Bull.) B.-S.; **Tyromyces** Karst., type *T. chioneus* (Fr. *sensu* Karst.) Karst. **Amylocystis** B.-S. (5); **Bjerkandera** Karst., type *B. adusta* (Willd.) Karst.; **Spongipellis** Pat., type *S. spumeus* (Sow.) Pat.; **Gloeoporus** Mont., type *G. conchoides* Mont.; **Hapalopilus** Karst., type *H. nidulans* (Fr.) Karst.

C. Subfamily FOMITOIDEAE: **Cryptoporus** (Peck) Hubbard, type *C. volvatus* (Peck) Shear; **Piptoporus** Karst. em. Pilat, type *P. betulinus* (Bull.) Karst.; **Ischnoderma** Karst., type *I. resinosum* (Fr.) Karst.; **Osmoporus** gen. nov. (6); **Pelloporus** Quél. *sensu* stricto, type *P. corrugis* (Fr.) B.-S.; **Fomes** (Fr.) Kickx *sensu* stricto, type *F. fomentarius* (L.) Kickx; **Fomitopsis** Karst., type *F. pinicola* (Schw.) Karst.; **Phaeolus** Pat., type *P. Schweinitzii* (Fr.) Pat.; **Inonotus** Karst., *I. cuticularis* (Bull.) Karst.; **Phellinus** Quél., type *P. igniarius* (L.) Quél.; **Leucophellinus** B.-S. (7); **Cyclomyces** Kunze & Fr., type *C. fuscus* Kunze & Fr.; **Cycloporus** (Pat.) Murr., type *C. Greenii* (Berk.) Murr.; **Coltricia** S. F. Gray (8); **Polystictus** Fr. (8); **Ganoderma** Karst. em. Pat., type *G. lucidum* (Leyss.) Karst.

D. Subfamily POLYPOROIDEAE: **Polyporus** Mich. *sensu* Donk, type *P. tuberaster* (Jacq.) Fr.; **Asterochaete** (Pat.) B.-S. type *A. megalopora* (Mont.) B.-S.

E. Subfamily CORIOLOIDEAE: **Pycnoporus** Karst., type *P. cinabarinus* (Jacq.) Karst.; **Cerrena** Mich. ex S. F. Gray (9); **Coriolus** Quél., type *C. versicolor* (L.) Quél.; **Corirolellus** Murr. type *C. sepium* (Berk.) Murr.; **Poronidulus** Murr., type *P. conchifer* (Schwein.) Murr.; **Trametes** Fr., type *T. suaveolens* Fr.; **Pseudotrametes** B.-S. (10); **Haploporus** B.-S. (11); **Hexagona** Fr., type *H. nitida* Mont.; **Antrodia** Karst., type *A. mollis* (Sommerf.) Karst.; **Funalia** Pat., type *F. mons-veneris* (Jungh.) Pat.; **Corioloopsis** Murr., type *C. occidentalis* (Klotzsch) Murr.;

<sup>1</sup> The abbreviation "B.-S." stands for A. S. Bondarzew and Rolf Singer.

**Baeostratoporus** B.-S. (12); **Abortiporus** Murr. (13); **Oxyporus** (Bourd. & Galz.) Donk em. B.-S., type *O. populinus* (Fr.) Donk; **Irpex** Fr. *sensu stricto*, type *I. lacteus* Fr.; **Hirschioporus** Donk em. B.-S., type *H. abietinus* (Dicks.) Donk; **Daedalea** Pers. ex Gray, type *D. quercina* (L.) Fr.; **Daedaleopsis** Schroet., type *D. confragosa* (Bolt.) Schroet.; **Lenzites** Fr. *sensu* Karst., type *L. betulina* (L.) Fr.; **Gloeophyllum** Karst., type *G. sepiarium* (Wulf.) Karst.

In addition to this, pore bearing fungi are transferred to some other suborders but Polyporineae. Thus, the genus **Boletopsis** Fayod is considered as belonging to the suborder Phylacteriineae, fam. Boletopsidaceae; **Scutiger** Paulet ex Murr. (14), **Bondarzewia** Sing. based on *Polyporus montanus* Quél., and **Polyphilus** Karst. (15) to the Clavariineae (Scutigeraceae); **Fistulina** Fr., based on *F. hepatica* (Huds.) Fr. to the Cyphellineae (Fistulinaceae), and **Porothelium** Fr., based on *P. fimbriatum* (Pers.) Fr. to the same suborder and family; **Sistotrema** Pers. em. B.-S., D. P. Rogers, based on *S. confluens* Pers., *Phlebiella* Karst. (16), **Byssocorticium** B.-S. (17), and **Vararia** Karst. (18) to the Corticiineae (Corticaceae); **Serpula** Pers. ex S. F. Gray (19), **Merulius** Hall. em. Fr. *sensu* Pat., based on *M. tremellosus* (Schr.) Fr., and **Merulioporia** B.-S. (20) to Corticiineae, family Meruliaceae. In addition, all the genera belonging to Boletaceae or Strobilomycetaceae are, of course, excluded from the Polyporaceae.

#### DIAGNOSES AND OBSERVATIONS

(1) *Fibuloporia* B.-S. Poriae acystidiatae, fibuligerae, aequiporae, molliusculae, sporis ovoideis, ellipsoideis v. subglobosis. Species typica: *F. mollusca* (Pers.) B.-S.

(2) *Amyloporia* B.-S. Poriae acystidiatae, amyloideae, sporis cylindricis v. allantoideis. Species typica: *A. calcea* (Fr.) B.-S.

(3) *Aporpium* B.-S. Poriae acystidiatae, haud fibuligerae, inamyloideae, sporis cylindricis v. allantoideis. Species typica: *A. canescens* (Karst.) B.-S.

(4) *Chaetoporellus* B.-S. Poriae cystidiatae v. hyphis excreticibus instructae, molles v. fragiles, fibuligerae. Species typica: *C. latitans* (Bourd. & Galz.) B.-S.

(5) *Amylocystis* B.-S. "Polypori" pileati, cystidiis amyloideis. Species typica: *A. lapponicus* (Rom.) B.-S.

(6) *Osmoporus* Sing. gen. nov. "Polypori" astipitati, intus brunnei, margine obtusi v. subacuti, indistincte crustati, poris crasso-parietalibus latiusculisque, interdum spurie stratosi, odorati, ad ligna coniferarum crescentes. Species typica: *O. odoratus* (Wulf.) comb. nov. Species alia: *O. caucasicus* (Bres.) comb. nov.

We had tried to revive Humboldt's genus *Ceratophora* which, however, is based on abnormal forms and, therefore, must be excluded.

(7) *Leucophellinus* B.-S. "Polypori" astipitati, poris trametoideis v. irpecoideis haud stratosi nec setosis, intus albi v. flavidi, sporis bi-tunicatis, hyalinis. Species typica: *L. irpicoides* (Bondarzew apud Pilát) B.-S.

(8) *Coltricia* S. F. Gray.—This name has to be substituted for *Polystictus* Fr. Gray's genus is valid and has priority over Fries' genus. The determination of the type species of this latter (*Polystictus perennis*) by Ames was illegal as Fries did not mention *P. perennis* in his "Novae Symbolae . . ." (1851). The first species mentioned and at the same time the best known of the species mentioned in "Novae Symbolae . . ." is *P. tomentosus* Fr. ex Fr., and it seems to be best to recognize this species as the type of the genus *Polystictus*. In doing so, we can use *Polystictus* sensu stricto for the species now composing the section *Onnia* of *Polystictus* which will have to be separated generically from *Coltricia* sooner or later. In this case, no new combinations would be required.

(9) *Cerrena* Mich. ex S. F. Gray.—This genus has to replace the later synonym *Phyllodontia* Karst., both being based on the same species, *Cerrena unicolor* (Bull.) Murr., which is the same as *Phyllodontia Magnusii* Karst.

(10) *Pseudotrametes* B.-S. "Polypori" trametoidei, vix umquam fibuligeri, sporis minutis, cylindricis, poris radialiter elongatis, intus albi, crassi, inodori. Species typica: *P. gibbosa* (Pers.) B.-S.

(11) *Haploporus* B.-S. "Polypori" trametoidei, vix umquam fibuligeri, sporis minutis, ovoideis, poris teretis, integris, intus albi, odorati v. inodori. Species typica: *H. odor* (Fr.) B.-S.

(12) *Baeostratoporus* B.-S. "Polypori" trametoideo-fomitei, astipitati, hyphis irregularibus, dense intricatis, intus flavi pallidive, demum brunnescentes, tenuissime stratosi. Species typica: *B. Braunii* (Rab.) B.-S.

(13) *Abortiporus* Murr.—This genus has to replace *Heteroporus* Láz., and the type species becomes *A. distortus* (Schwein.) Murr. Other species: *A. biennis* (Bull.) comb. nov., *A. borealis* (Wahl.) comb. nov., *A. humilis* (Peck) comb. nov.

(14) *Scutigera* Paulet ex Murr.—Wm. Bridge Cooke proposes the generic name *Albatrellus* Mich. ex Gray for this group. We prefer *Albatrellus fuliginus* (Pers.) S. F. Gray as the type species

of the genus, rather than *Albatrellus albidus* (Pers.) S. F. Gray, because thus we avoid the use of a genus that is entirely heterogeneous, consisting of two species so little related that they have been classified in different families in our scheme of the pore fungi. Besides, we would avoid unnecessary new combinations for fungi now well known as *Scutiger* species. The type species of *Scutiger* remains to be *S. tuberosus* respectively *S. pes-caprae* (Pers.) B.-S. *Albatrellus* becomes a synonym of *Polyporus*.

(15) *Polypilus* Karst. We prefer *Grifola platypora* as the type species of Gray's genus *Grifola* because this avoids the use of a species as type species that is the only representative of the genus *Polypilus* within *Grifola*, while all the rest of the species listed by Gray belong to widely different genera. The largest recognizable element within *Grifola* consists of species now classified as *Polyporus* (*squamosus*, *varius*). Therefore, we maintain *Polypilus* Karst. with the type species *P. ramosissimus* (Dicks.) Karst., and put *Grifola* (p.p.) in synonymy with *Polyporus* Mich. ex Fr. *sensu* Donk.

(16) *Phlebiella* Karst. (fide D. P. Rogers, The Genera *Trechispora* and *Galzinia* (Thelephoraceae), to be discussed in *Mycologia* 36 (1), 1944) is the correct generic name for the species referred to *Trechispora* Bond. & Sing. non Karst. (*T. candidissima* (Schwein.) B.-S., *T. trachyspora* (Bourd. & Galz.) B.-S., etc.), since the type species of *Trechispora* Karst. belongs to the neighborhood of *Sistotrema* as defined by Bondarzew and Singer, and D. P. Rogers. Type species of *Phlebiella* is: *Phlebia vaga* Fr.

(17) *Vararia* Karst. (= *Asterostromella* Hoehn. & Litsch.).—See R. Singer, Type studies on Basidiomycetes II, *Mycologia* 35: 160, 1943.

(18) *Byssocorticium* B.-S. Poriae, Corticia, a Nothotrechisporis ampullis absentibus, a generibus Poroidearum consistentia byssosidea recedentia. Species typica: *B. atrovirens* (Fr.) B.-S.

(19) *Serpula* Pers. ex S. F. Gray.—Based on *Merulius lacrymans*, this genus evidently has priority over *Gyrophana* Pat.

(20) *Merulioporia* B.-S. 1941, based on *M. taxicola* (Pers.) B. & S. Murrill's genus of the same name (*Mycologia* 34: 596, 1942, spelled *Meruliporia*), based not on *M. taxicola*, but on *M. incrassata* (Berk. & Curt.) Murr., is different.

## THE GENERA TRECHISPORA AND GALZINIA (THELEPHORACEAE)<sup>1</sup>

DONALD P. RÖGERS

(WITH 14 FIGURES)

The genus *Trechispora* is made up of resupinate hymenomycetes possessing urniform basidia. That peculiar type of basidial development and structure best referred to as the urnigera type was first made the basis of taxonomic segregation in 1911, when Bourdot & Galzin (Bull. Soc. Myc. Fr. 27: 243) described the "Groupe *Urnigera*" within the genus *Corticium*, and assigned to it the species *C. octosporum*, *C. coronilla*, *C. diademiferum*, and *Odontia Brinkmanni* Bonorden (Hedwigia 15: 76. 1876) and Höhnelt & Litschauer (Ann. Myc. 4: 291. 1906) had already described species with the many-spored, coronate basidia and the compact, proliferative basidial clusters characteristic of the group in question, but had failed to mention the distinguishing developmental stages and final form of the basidia. Bourdot & Galzin subsequently recognized *Urnigera* sections in other genera of the lower hymenomycetes; that they did not combine these into a single genus is probably to be explained by their declared practice (Hym. Fr. [i]. [1928]) of following the classification of Patouillard. In 1934 I discussed the desirability of bringing together all the urnigera fungi (Univ. Iowa St. N. H. 16: 176), and in 1935, after correspondence with Dr. M. A. Donk and at his suggestion, adopted the name *Sistotrema* for both resupinate and pileate members of the group (Univ. Iowa St. Nat. Hist. 17: 19). It now appears more convenient to allow a separation between the pileate genus *Sistotrema* and the resupinate species; for the latter the name *Trechispora*, apparently the earliest available, has been adopted. Although in 1935 I possessed a considerable quantity of material of these fungi, the distinctness of certain of the accepted species remained in some doubt, and others I could

<sup>1</sup> Contribution from the Department of Botany, Brown University.

not properly attempt to define without examination of their type specimens. Accordingly, only two species were then treated. Since that time, from study of types and of a much larger series of specimens it has become possible to distinguish, or with some assurance to reduce to synonymy, all described species of urnigera basidiomycetes. Three such fungi have already been assigned to *Trechispora* by Rogers & Jackson (*Farlowia* 1: 282, 288, 328, 1943), and these and others are herein described.

Since the character by which species of *Trechispora* may be recognized among the heterogeneity and confusion of the lower hymenomycetes is a peculiar basidial morphology, the segregation of this genus and *Sistotrema* is only a lesser continuation of the evaluation of basidial types commenced by the Tulasnes and Patouillard. *Trechispora* possesses (although probably in slighter degree) the same sort of autonomy which may be claimed for *Calocera*, *Sebacina*, *Helicobasidium*, or *Tulasnella*, none of which could be separated from its parent genus except by its basidia. Once the characters of a number of organisms become accurately known, the classification of these organisms amounts to neither more nor less than the embodiment of a hypothesis concerning their phyletic relations. For the fungi here brought together in *Trechispora* mycologists have adopted one or the other of two such hypotheses. According to the first, which is implicit in more conservative classifications, hymenial configuration is a reliable indication of kinship. That is, all hymenomycetes with a smooth hymenium (Thelephoraceae) are descended from one common ancestral form or group; all those with granulose-to-spinose hymenium (Hydnaceae) are descended from another; and all those with reticulate-to-poroid hymenium (Polyporaceae) have a third. On this hypothesis such groups of characters as those which mark the urnigera forms (or, for a second example, Patouillard's Phylacteriaceae) arose independently within the several families, and the micromorphologic resemblances between smooth and hydroid, or smooth and polyporoid, urnigera species are the result of accidental convergence. According to the second hypothesis, which underlies the classification presented in this paper, the urnigera basidium and the other characters regularly associated with it are a reliable indication of kinship, and the



variations in hymenial configuration (such as those which have served to separate *Corticium coronilla* from *Grandinia Brinkmanni*) are comparatively trivial and recent variations in a single original type. On this hypothesis it is the urnigera members of the Thelephoraceae, Hydnaceae, and Polyporaceae that are descended from one common ancestral form or group, and variation in hymenial configuration that has brought about accidental convergence. On the first hypothesis *Corticium coronilla*, *C. cremoricolor*, and *Tomentella* are closer kin to each other than is the first to *Grandinia Brinkmanni* or *Poria onusta*, the second to *Radulum membranaceum*, and the third to *Caldesiella*; on the second the opposite is true. These two points of view are presented in order to make clear the basis for the present association of species.

Unless the disadvantages of change are generally held to be greater than the disadvantages of an unnatural classification, the older families of the Agaricales will some day have to be discarded. Until that time, the finding of places for genera like the present one will be difficult. Not because *Trechispora* has any but the remotest kinship to *Thelephora*, but because those urnigera species with smooth hymenium are probably the primitive ones, and are in the majority, *Trechispora* is temporarily assigned, in the artificial taxonomy which must be tolerated until it can be superseded, to a place in the Thelephoraceae.

*Galzinia* may not be closely related to *Trechispora*. But because its basidia consist of a basal vesicle and an apical expanded sporiferous portion, connected by a neck of variable length, specimens of *Galzinia* might at times be sought in *Trechispora*, and the two genera are accordingly included in the one paper.

I am indebted to the Oregon General Research Council for grants in aid of mycological collection and research at Oregon State College; to Dr. D. V. Baxter of Michigan, Mrs. Harvey Bingham of Western Reserve, Dr. J. N. Couch of North Carolina, Dr. G. D. Darker of the Missouri Botanical Garden, Dr. B. O. Dodge of the New York Botanical Garden, Professor F. O. Grover of Oberlin, the late Professor V. Litschauer of Innsbruck, Dr. G. W. Martin of Iowa, Dr. F. J. Seaver of the New York Botanical Garden, Dr. E. V. Seeler, Jr., of Harvard, Mr. J. A.

Stevenson of the United States Department of Agriculture, and Dr. L. E. Wehmeyer of Michigan for material studied in the preparation of these descriptions; to Dr. H. S. Jackson of Toronto for many suggestions, for the loan of Dr. Rosemary Biggs's series of *Corticium coronilla*, and for abundant other material; to Dr. D. H. Linder of Harvard for the privilege of examining his own collections and the many valuable specimens in the Farlow Herbarium; to Dr. W. H. Snell of Brown for generous provision of facilities and opportunity for mycological research; and to Alpha Mae Rogers for preparation of the illustrations.

TRECHISPORA Karst. Hedwigia **29**: 147. 1890; Bidr. Känned. Finl. Nat. Folk **54**: 178. 1893; Bond. & Sing. Ann. Myc. **39**: 48. 1941, quantum ad typum, descr. et spec. caeteris excl.; Rogers & Jackson, Farlowia **1**: 328. 1943.

*Corticium* [sect.] *Urnigera* Bourd. & Galz. Bull. Soc. Myc. Fr. **27**: 243. 1911; Hym. Fr. 235. [1928]; Donk, Nederl. Mycol. Ver. Med. **18-20**: 137. 1931.

*Heptasporium* Bref. Unters. **15**: 111. 1912.

*Gloeocystidium* [sect.] *Urnigera* Bourd. & Galz. Hym. Fr. 264. [1928].

*Poria* sect. *Urnigerae* Donk, Nederl. Mycol. Ver. Med. **22**: 220. 1933.

*Sistotrema sensu* Donk in litt. ex Rogers, Univ. Iowa St. N. H. **17**: 19. 1935, typo excl.; Bond. & Sing. Ann. Myc. **39**: 47. 1941, tantundem.

Type: *T. onusta* Karst.

Fructification resupinate, even (corticoid), granulose (granuloid), spinulose (hydroid), or porose (poroid), in texture pruinose, arachnoid, or fragile-membranous; hyphae with strong clamps throughout, often ampullate at the septa, short-celled and abundantly branched except for the more regular basal strands; basidia mostly arising in compact clusters through proliferation of the subtending clamps, at first subglobose or ellipsoid, developing a narrow tubular prolongation at whose summit are borne 5-8, or more rarely only 4, peripheral sterigmata; spores mostly even and thin-walled, rarely angular or slightly thick-walled; gloeocystidia present in some species.

*Trechispora* is chiefly characterized by the small, distinctly uniform basidia with a long-persistent subglobose or ellipsoid



early stage in development. Most species show also five to eight sterigmata; but with them must be included species similar in other respects but having only four. All those studied have the immature basidia of various ages borne in clusters, as a result of their development through clamp-proliferation (cf. *Mycologia* 28: 347-362. 1936); but this constant character is probably not an essential one, and in some species other basidia are more loosely arranged at various levels on the fertile hypha. From *Sistotrema sensu strictiore Trechispora* differs in the resupinate basidiocarps; from *Pellicularia*, *Corticium calceum sensu* Bourd. & Galz., *C. subinvisibile*, and certain other corticioid fungi having more than four sterigmata, by the form of the basidium and the two distinct phases in its development.

In 1935 I published (l.c.) an emendation of *Sistotrema* Pers. (Roem. N. Mag. Bot. 108. 1794; Tent. Disp. Meth. Fung. 28. 1797; Syn. Meth. Fung. 550. 1801; Myc. Eur. 2: 191. 1825) ex Fr. (Syst. Myc. 1: 426. 1821) to include the fungi here assigned to *Trechispora*, with which *Sistotrema confluens* agrees in basidial morphology. There was, and still is, some doubt concerning the type species of Persoon's genus. In his original diagnosis (l.c.) he wrote "pileo suberoso," a phrase more applicable to his second species, *S. cinereum* (= *Boletus unicolor* Bull.) than to the first, *S. confluens*, which Persoon later (Syn. Meth. Fung. 551. 1801) characterized by "pileo carnosio flexuoso." Nevertheless, *S. confluens* is retained by Persoon in all his later treatments, and is the only species included by Fries in 1821 (l.c.) and by certain other authors. Fries may then be considered to have established this, rather than the other species originally included in the genus, as the generic type. Fries sought to do even more; with his undeviating punctiliousness he ascribed the genus to himself (l.c.); but both genus and species are, as he indicated under the latter, Persoon's, and should be written "Pers. ex Fr."

In referring both resupinate and pileate species to *Sistotrema*, Donk and the writer were influenced not only by the essential identity of the basidia, but also by Bourdot's account (Hym. Fr. 437. [1928]) of replacement of resupinate fructifications by the stipitate ones of *S. confluens*. Such collections of that species

as have been examined give no evidence of any intergradation with resupinate basidiocarps, and it seems that the connection cannot be regarded as proved. Consequently resupinate forms may be susceptible of segregation from the pileate *Sistotrema*, and such segregation has been adopted by Rogers & Jackson (l.c.) and for the present discussion. The further subdivision of the resupinate group on the basis of basidiocarp morphology would, however, clearly cut across lines of affinity. Thus, as pointed out under the several species, *Trechispora onusta* (porioid) and *Grandinia raduloides* are scarcely distinguishable except by gross morphology, and possess in common a variation of the urnigera basidium present in no other species; similarly one portion of a fructification may possess the characteristics of *Grandinia Brinkmanni* and the remainder those of *Corticium coronilla*. Consequently all the resupinate species are treated not merely in the same series or subfamily, but in the same genus.

For this genus the name *Trechispora* Karst. clearly has priority. *Trechispora* is monotypic; the type specimen of *T. onusta* has been examined, and belongs here. The name is unfortunate, since neither the type nor most other species are "rough-spored"; but it is that rare thing among resupinates, a generic name whose application can be fixed beyond question. So much cannot be said for *Heptasporium* Bref., which in addition is a name almost as inept. Ineptness is not, however, the only possible objection to the name *Trechispora*. From a strictly etymological point of view, *Trechispora* is an orthographic variant of *Trachyspora* Fuckel 1861 of the Uredinales; the lexicon gives Τρηχυσ as "Ion. for Τραχυσ." Yet according to Art. 70(3) of the Rules, "in deciding whether two . . . slightly different names should be treated as distinct or as orthographical variants, the essential consideration is whether they may be confused with one another or not"; there seems no reason to anticipate confusion of these, differing as they do in two letters and in pronunciation, and especially since the genera to which they are applied belong to two different subclasses; and *Trechispora* and *Trachyspora* are no more mere orthographic variants than are *Urvillea* and *Durvillea*, expressly held by the Rules to be distinct. A more serious objection to the use of Karsten's name might be based on Bresadola's

conjecture (Ann. Myc. 6: 41. 1908) that "original specimens" consisted of not one fungus but two. Bresadola reported that such specimens "agree in [basidia, spores, and hyphae], but there is present in them a substratum, especially evident at the sides, dirty lilaceous in color, consisting of hyaline hyphae which bear subglobose, hyaline, aculeolate conidia  $4 \times 3-4 \mu$  in diameter. These [conidia] perhaps were taken for spores by Karsten when he said that the spores are echinulate—which indeed is false." Now the specimen of *T. onusta* in the Patouillard collection, bearing collection-data which permit the assumption that it is a part of the type, certainly has at the edge mycelium without clamps which does not belong to the basidiocarp. This mycelium, however, bears no conidia; and since it is all very slender, while the dimensions given by Karsten,  $2-7 \mu$ , correspond to those of the clamp-bearing hyphae of the basidiocarp, there seems no sufficient evidence that Karsten confused two fungi in writing his description. Furthermore, Bresadola's descriptions of the basidiospores as "very minutely asperulate or smooth," whereas they are quite smooth, and of the basidia as "subglobose . . . as in *Tulasnella*," attest the inaccuracy, or at least the incompleteness, of his own observations, and, in respect to the spores, seem to convict him also of Karsten's error in describing the outline. Bresadola does not, as a matter of fact, assert that *T. onusta* is a name based on two species erroneously taken to be one, and the portion of the type examined for that possibility affords no adequate basis for rejecting Karsten's genus and species as nomina confusa. Since the alternative to recognizing *Trechispora* is accepting *Heptasporium* and an unrecognizable type species, it seems imprudent to magnify these acknowledged difficulties.

The fungi of this genus are bewildering in their variability; in particular I have thus far been unable to find any natural cleavage within the *Corticium coronilla* complex. In the earlier discussion it was stated that "The specific limitations of some of these species are not well established and the distinctness of several [is] more than a little doubtful"; this was not to say, however, as an inadvertent misinterpretation of that paper has paraphrased it, that *C. diademiferum* and *C. niveo-cremum* were

included under the name *Sistotrema coronilla*, a species that included nothing but *C. coronilla*.

Relying upon Karsten's account of the spores of *Trechispora*, Donk (Nederl. Myc. Ver. Med. 22: 221. 1933) listed that genus under *Poria* sect. *Subtiles* Bourd. & Galz. emend. Donk, a group limited by him to rough-spores species. In this Bondarzew & Singer (l.c.; cf. p. 73 of this paper) followed Donk; they used Karsten's genus for those resupinate hymenomycetes with asperulate spores and ampullate hyphae previously included in *Corticium* sect. *Humicola* Bourd. & Galz. and related groups within *Grandinia* and *Poria*. As shown, however, by the specimen here cited, and by Bourdot & Galzin's description of *T. onusta*, *Trechispora* is a genus rather of urnigera species, and another name must be used for the section *Humicola* and congeneric forms.<sup>2</sup>

<sup>2</sup> Five published generic names must be considered as possibly applicable to *Trechispora sensu* Bondarzew & Singer:

(1) *Merisma* Pers. Myc. Eur. 1: 155. 1822. This name is, however, antedated by *Merisma* Pers. ex Gray, Nat. Arr. Br. Pl. 1: 653. 1821, whose type must be selected from the two species *M. cristatum* (Pers. ex Fr.) Gray and *M. foetidum* Pers. ex Gray. Since the first of these species is probably the same as *Sebacina incrustans* (Pers. ex Fr.) Tul. (cf. Burt, Missouri Bot. Gard. Ann. 2: 752. 1915; Bourd. & Galz., Hym. Fr. 231. [1928].), to adopt it as the type would make necessary either discarding the generic name *Sebacina* Tul. or conserving *Sebacina*, [1871], against *Merisma*. Therefore *M. foetidum* is hereby designated as the lectotype of *Merisma* Pers. ex Gray. Since *M. foetidum* is probably the same as *Thelephora palmata* [Scop.] Fr., *Merisma* is in either case not available for *Corticium* sect. *Humicola* and related species. *Merisma* could be used here only by conservation of *Merisma* Pers., 1882, with the lectotype *M. fastidiosum* (Pers. ex Fr.) Pers., against *Merisma* Pers. ex Gray, 1821.

To avoid possible nomenclatorial complexities that might arise from the existence of *Thelephora* trib. *Merisma* [Pers.] Fr., Syst. Myc. 1: 432. 1821, *T. palmata* [Scop.] Fr. is hereby designated the lectotype of that Friesian tribe.

(2) *Athelia* Pers. Myc. Eur. 1: 83. 1822. Under the name *Athelia* its author assembled a most heterogeneous group of fungi, of which *A. strigosa*  $\beta$  *musciigena* is now known as *Peniophora byssoides*, *A. velutina* as *P. velutina*, *A. Typhae* as *Episthele Typhae*, *A. citrina* possibly as *Corticium bicolor*, and *A. sericea* as *Corticium sulphureum*; the remaining names may all represent lost species. Since the name *Athelia* is not at present maintained for any of its recognizable species, and seems never to have been typified, it is available for any genus which, like the one here under discussion, includes one of its species. The name *Athelia* means, however, "without papillae"; since the

(Footnote continued on page 78)

elevations on the hymenium of *A. sericea* (*Corticium sulphureum*) in some of its varied phases are sufficiently prominent to have caused Fries to assign it to the genus *Phlebia* (see the following discussion under *Phlebiella*), *A. sericea* may be regarded as atypical, and is consequently here rejected as a possible lectotype for *Athelia*. Since *A. sericea* seems to be the only *Humicola* form in its genus, *Athelia* then becomes unavailable for the fungi in question (*Trechispora sensu* Bond. & Sing.).

It would be possible at this time to fix the application of Persoon's generic name by the formal designation of a lectotype for *Athelia*. It seems advisable, however, to refrain from making such a decision until the actual need arises for a generic name for some other species of that group.

(3) *Cristella* Pat. Hym. d'Eur. 151. 1887; type, *C. cristata* ([Pers.] ex Fr.) Pat. This is certainly the preferable name for the genus under discussion; it has recently been used as such by Cooke (*Mycologia* 35: 288. 1943.). From Patouillard's figures (Tab. Anal. 2: 25. fig. 559. 1886; Essai. Taxon. 41. 1900.), descriptions, and specimens (two collections, in the Patouillard collections of the Farlow Herbarium), there can be no doubt of the fungus he had in mind in describing the genus: it was the form described by Bourdot & Galzin, Hym. Fr. 230, as *Corticium fastidiosum*. Since, however, the only possible generic type is *Thelephora cristata* [Pers.] Fr., which presumably is a *Sebacina*, *Cristella* must fall into synonymy with that genus. At least, that seems to be the meaning here of the type concept. It is also in accordance with the principle settled upon at the Amsterdam congress, for dealing with new binomials erroneously applied (cf. Science n. s. 83: 417. 1936, paragraph 6; Zesde Int. Bot. Congr. Proc. 1: 347-354. 1936.). That principle, stated in general terms, is that where a typonym (here *Thelephora cristata*) associated by an author with a new name (here *Cristella cristata*) is not properly applicable to the author's material and description (here *Corticium fastidiosum*), it is the typonym, rather than the misdetermined material, which determines the application of the new name. Now *Thelephora cristata* probably is the same as *Sebacina incrustans*. Ergo, *Cristella* = *Sebacina*.

(4) *Soppittiella* Mass. Br. Fung.-Fl. 1: 106. 1892, an ill defined and heterogeneous group of five species. Both the description and the species enumerated seem to include *Sebacina* and *Tomentella*, and perhaps also a *Humicola* form. One of the species is *S. fastidiosa* Mass., said to be the same as "*Thelephora fastidiosa* Berk.". Whether by his citation of Berkeley as the author of that species Massee intended to reflect doubt of the correctness of Berkeley's determinations cannot be determined from the context; if he intended to refer to *T. fastidiosa* [Pers.] Fr., a *Humicola* form, *Soppittiella* must be considered as a possible name for *Trechispora sensu* Bond. & Sing., even though *T. fastidiosa* is excluded by Massee's description. Massee segregated the genus from *Thelephora*, "from which it differs in being soft and subgelatinous when moist, and compact, not strigose pileus." In the absence of other motives for selecting a species as the type of a genus, it has been held desirable to choose that species which the author illustrated, as presumably the one best representing his intended concept. There seem to be no other allowable motives here, and *S. cristata* ([Pers.] ex Fr.) Mass. is therefore hereby designated as the lectotype of *Soppittiella*. That species is of course the same *Thelephora*



KEY TO THE SPECIES<sup>3</sup>

1. Basidiocarps pileate. . . . . *Sistotrema confluens*.
1. Basidiocarps resupinate. . . . . 2
  2. Basidiocarps alveolate (porioid), with delicate dissepiments separating angular pores. . . . . 3
  2. Basidiocarps hydroid, with minute distinct spines. . . . . 5
  2. Basidiocarps even (corticoid) or granulose (grandinoid). . . . . 6
3. Basidia with short, cylindric distal portion; spores subglobose or broadly ellipsoid, 5-7  $\times$  4.5-6.5  $\mu$ ; pores bright yellow. . . . . 1. *T. onusta*.

*cristata* on which Patouillard based his *Cristella*, and the status of Masee's genus is the same as that of Patouillard's.

(5) *Phlebiella* Karst. Hedw. 29: 271. 1890; type, *Phlebia vaga* Fr. Karsten spelled the name "*Phlebriella*"; since he wrote also "*Phlebia vaga* Fr.," it is clear that the intrusive *r* is a lapsus calami, subject to correction under Art. 70 of the Rules. As Fries described *Phlebia vaga* in 1874 (Hym. Eur. 625.), that species was then certainly the same fungus as the one described by Bourdot & Galzin as *Corticium sulphureum*, and by Burt as *Hypochnus fumosus* (cf. Bourdot & Galzin, Hym. Fr. 234. [1928]; Rogers & Jackson, Farlowia 1: 304, 308. 1943.), a member of the *Humicola* group for which a generic name is here being sought. The definitive publication of *Phlebia vaga* is, however, that in Syst. Myc. 1: 428. 1821; and the description there leaves the name of somewhat more doubtful application. But if the 1874 description be taken as an elucidation of the one published in 1821, *Phlebia vaga* can be regarded as a species satisfactorily established, and Karsten's genus as satisfactorily typified by this member of the *Humicola* group. *Phlebiella* Karst. is then the correct name for *Trechispora sensu* Bond. & Sing.—that is, for at least most species of *Corticium* sect. *Humicola* Bourd. & Galz., and for their congeners now segregated in *Poria* and *Grandinia*.

In publishing his genus Karsten published no binomials, a neglect that does not invalidate the genus under the Rules. It may be inferred that he intended to call the type species *Phlebiella vaga* (Fr.) Karst., and that name is here published and attributed, properly, as it seems, to Karsten.

<sup>3</sup> Three species are included in the key for completeness, but are not described: (1) *Sistotrema confluens* Pers. ex Fr.; and two porioid forms of which no material was available for study, (2) *T. albo-pallescens* (Bourd. & Galz.) comb. nov. (= *Poria albo-pallescens* Bourd. & Galz. Bull. Soc. Myc. Fr. 41: 216. 1925; Hym. Fr. 656. [1928]; Donk, Nederl. Mycol. Ver. Med. 22: 220. 1933; = *Sistotrema albo-pallescens* (Bourd. & Galz.) Bond. & Sing. Ann. Myc. 39: 47. 1941), and (3) *T. albo-lutea* (Bourd. & Galz.) comb. nov. (= *Poria albo-lutea* Bourd. & Galz. Bull. Soc. Myc. Fr. 41: 217. 1925; Hym. Fr. 657. fig. 181. [1928]; = *Sistotrema albo-lutea* (Bourd. & Galz.) Bond. & Sing. Ann. Myc. 39: 47. 1941). From the descriptions (for which the Hyménomycètes de France should be consulted) these porioid species seem to be quite distinct. *Corticium suecicum* Litsch. and *C. niveo-cremeum* Höhn. & Litsch. are both included in the key and described, because they resemble, and may be sought in, this genus, and because Bourdot & Galzin treated them as urnigera forms.

3. Basidia with distal portion strongly expanded at the summit; pores white, creamy, or finally fulvous..... 4
4. Spores subglobose, even,  $2.5-4.5 \times 2-4 \mu$ ; pores white or creamy..... *T. albo-pallescentis*.
4. Spores subglobose, even, larger than  $4.5 \mu$ , or rough-walled, or oblong, or rarely obovate and  $4.5 \mu$  or less in length; pores in all but rough-spores specimens becoming sulfur to fulvous..... *T. albo-lutea*.
5. Spores fusiform..... 2. *T. raduloides*.
5. Spores subglobose or ellipsoid..... 3. *T. muscicola*.
6. Spores tetrahedral..... 4. *T. subtrigonosperma*.
6. Spores subglobose (obovate or very short ellipsoid)..... 5. *T. diademiifera*.
6. Spores even, ellipsoid or more elongate... 7
7. Gloecystidia present..... 8
7. Gloecystidia lacking..... 9
8. Basidia with 6-8 sterigmata  $3-4 \mu$  long; spores depressed or curved,  $4.5-6 \times 2-3 \mu$ ..... 6. *T. coronifera*.
8. Basidia with 4 longer sterigmata; spores straight,  $5.5 \times 3 \mu$  or larger..... 7. *T. Sernanderi*.
9. Basidia formed in compact clusters through proliferation of the subtending clamps, distinctly urniform; spores oblong-ellipsoid to subcylindric, straight or slightly depressed,  $3.5-7 \times (1.5-2.3) (-4.5) \mu$ ..... 8. *T. Brinkmanni*.
9. Basidia borne at various levels, in looser clusters, narrow-urniform or in part clavate; spores strongly curved, or straight and  $5.5-9 \times 2.5-3.5 \mu$ , or oblong..... 10
10. Basidia narrow-urniform; spores strongly curved..... 9. *T. Hirschii*.
10. Basidia frequently or always claviform; spores not much curved..... 11
11. Basidia in part urniform, in part claviform, variable in length; spores cylindric, straight or slightly curved..... 10. *Corticium niveo-cremum*.
11. Basidia clavate, uniform in length; spores oblong..... 11. *Corticium suecicum*.

1. TRECHISPORA ONUSTA Karst. Hedwigia 29: 147. 1890; Bidr. Känned. Finl. Nat. Folk 54: 179. 1893. (FIG. 1)

*Poria onusta* (Karst.) Sacc. Syll. Fung. 11: 95. 1895; Bres. Ann. Myc. 6: 41. 1908; Bourd. & Galz. Bull. Soc. Myc. Fr. 41: 218. 1925; Hym. Fr. 658. [1928]; Baxter, Mich. Acad. Papers 15: 222. 1932.

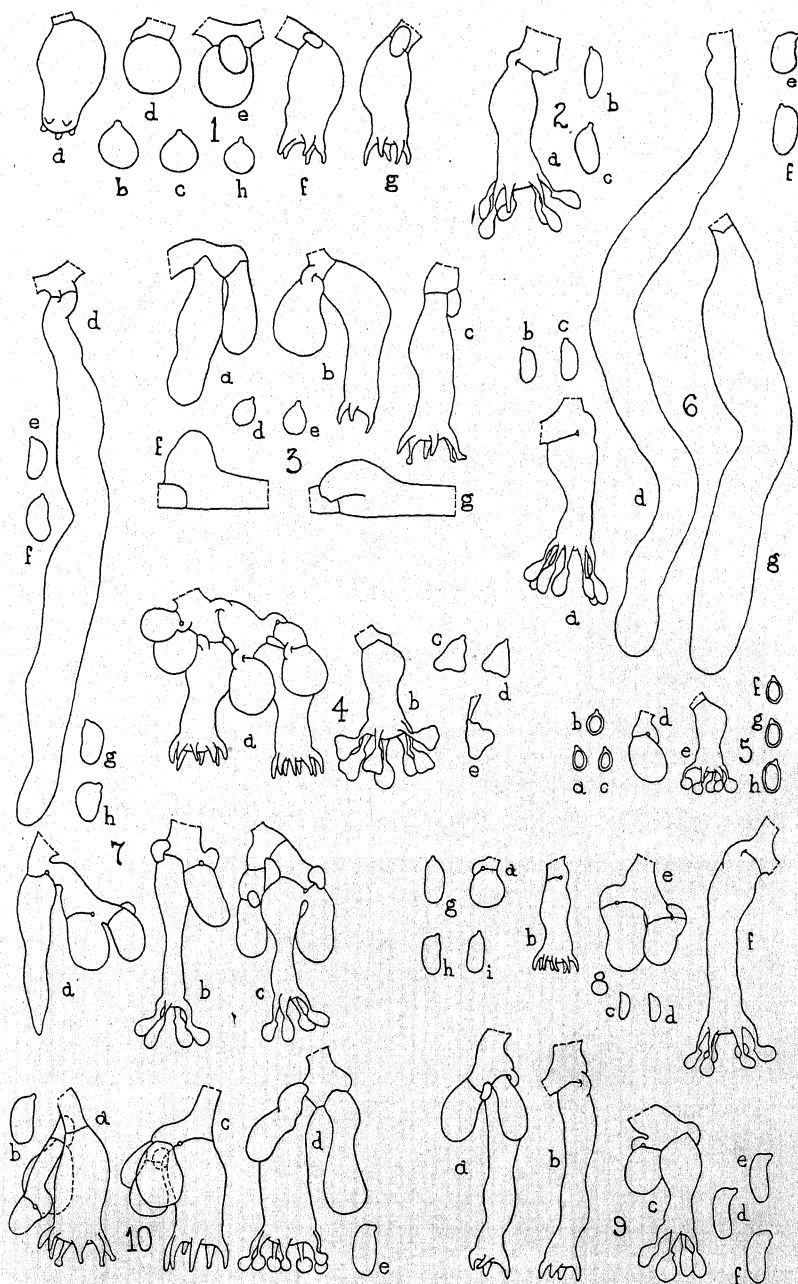


FIG. 1. *Trechispora onusta*; 2, *T. raduloides*; 3, *T. muscicola*; 4, *T. subtrigonosperma*; 5, *T. diademifera*; 6, *T. coronifera*; 7, *T. Sernanderi*; 8, *T. Brinkmanni*; 9, *T. Hirschii*; 10, *Corticium niveo-cremereum*.



Fructification porioid, the margin byssoid, creamy, the pores angular, shallow, with walls very thin and fragile, ochraceous-yellow (Cream Buff to Antimony Yellow R in old material); hyphae  $2-6.5\ \mu$ , in part collapsed, mostly thin-walled but with some elements a little thick-walled, with clamps throughout and at times strongly ampulliform; occasional sterile basidia with acuminate prolongation tipped with a small mass of refractive material; fertile basidia arising as broad-ellipsoid bodies about  $12 \times 9\ \mu$ , mostly laterally attached to the parent cell, later with a short obtuse-cylindric prolongation not sharply delimited at the base,  $4.5-5\ \mu$  in diameter, the mature basidia  $14-22 \times 8-9\ \mu$ , bearing more than 4 stout sterigmata  $4.5\ \mu$  long; spores even, thin-walled, subglobose or short-oblong, distinctly flattened on the inside,  $5-7 \times 4-6\ \mu$ .

On dead pine needles and wood of *Salix caprea*.

Specimens examined: Finland (Mustiala, in *Salice capr.*, P. A. Karsten, **type**, FH-P), Poland (Oct., Eichler, ex herb. G. Bresadola 86, NY).<sup>4</sup>

A poor *Poria*, well segregated from that genus, but infelicitously named, since the spores are smooth. There appear to be reports of urnigera basidia in only the three species of *Poria* treated in Bourdot & Galzin; from all others, unless microscopic characters have been neglected by students of the group, these three should be readily distinguishable by the basidia. From *T. albo-pallescentis* *T. onusta* should differ in color and in larger basidia and spores; from *T. albo-lutea* it should be distinguishable by the cylindric rather than expanded prolongation of the basidium, by the mycelium which lacks "guttulate"—i.e., gloeocystidioid—segments, and perhaps by the greater diameter of the larger hyphae.

## 2. *Trechispora raduloides* (Karst.) comb. nov. (FIG. 2)

*Hydnum raduloides* Karst. Soc. Faun. Fl. Fenn. Med. 9: 110. 1883.

<sup>4</sup> Herbaria from which specimens are cited have been indicated by the following standard abbreviations: BPI, Bureau of Plant Industry, U. S. Department of Agriculture; FH, general collections of the Farlow Herbarium, Harvard University; FH-B, its Burt collection; FH-H, its Höhnelt collection; FH-P, its Patouillard collection; NY, New York Botanical Garden; TRT, cryptogamic herbarium of the University of Toronto.

*Grandinia raduloides* (Karst.) Bourd. & Galz. Hym. Fr. 412. [1928]; Miller, Mycologia 25: 361. pl. 43, fig. 1. 1933; Miller & Boyle, Univ. Iowa St. N. H. 18: 13. pl. 1, fig. 10. 1943.

Fructification composed of a fragile, byssoid-membranous subiculum and terete or irregular, fragile, slightly tapered spines sometimes with byssoid tips, the spines, subiculum, and margin creamy buff, or with small areas on the spines darkened; both spines and subiculum fertile; hyphae with fairly rigid walls but often shrunken content, with prominent clamps throughout, 2.5–5  $\mu$  in diameter and swollen at many septa to 7  $\mu$ , in part with yellow-granular, resinoid content like that of gloecystidia; basidia in small clusters, when immature stipitate-ovate, forming a clavate or abruptly expanded prolongation, when mature 12.5–27.5  $\mu$  long, the neck 5  $\mu$  in diameter, the base 5.5–8  $\mu$ , the summit 5.5–7  $\mu$ , bearing usually 8 sterigmata 4–5  $\mu$  long and recurved; spores fusoid, slightly thick-walled, 6–8.5  $\times$  2.5–3  $\mu$ .

On wood of broad-leaved trees.

Specimens are at hand from Ontario and Iowa.

Basidia distinctly urniform, and more like those of some specimens of *T. Brinkmanni* than like the short-necked structures which characterize the similarly hydroid *T. muscicola*. Readily distinguishable by the spores.

### 3. *Trechispora muscicola* (Pers.) comb. nov. (FIG. 3)

*Hydnum muscicola* Pers. Myc. Eur. 2: 181. 1825.

*Grandinia muscicola* (Pers.) Bourd. & Galz. Bull. Soc. Myc. Fr. 30: 252. 1914; Hym. Fr. 411. fig. 112. [1928]; Bourd. Bull. Soc. Myc. Fr. 48: 219. 1932.

Fructification consisting of delicate terete spines, obtuse or subacute, about 0.5 mm. long, borne on a fragile-membranous, separable subiculum, the spines, sterile margin, and subiculum when dry strongly ochraceous; hyphae in part completely collapsed, in part distinct, 2.5–4  $\mu$ , with distinct ampullae or inflated clamps at the septa often up to 10  $\mu$  in diameter; immature basidia relatively large, broadly ellipsoid or obovate, 12–14  $\times$  7–9  $\mu$ , later with a short subcylindric prolongation only slightly or not at all expanded at the summit, at maturity 16–24  $\times$  6–8  $\mu$ , bearing 5–6 (?–8) short subulate sterigmata; spores ellipsoid, basally attenuated, 4–5.5  $\times$  3–3.5  $\mu$ .

On vegetable debris.

Specimens examined: France (Perseviaille, Aveyron, *Galzin* 16455, det. Bourdot 17785, ex herb. L. Maire, FH; Bouisson,

Aveyron, *Galzin 16261*, ex herb. Bourdot *15202*, C. G. Lloyd *24356*, BPI).

*Trechispora muscicola* closely resembles *T. onusta* in color, texture, hyphae, form of spores, and especially in basidia with relatively large basal portion and short unexpanded prolongation. Although the spores are smaller in the present species, there would be slight grounds for separating the two if it were not for the different hymenial configurations; they are certainly related to each other more closely than either is to any other species at hand or adequately described in *Poria* or *Grandinia*. With its minute but well developed spines *T. muscicola* is a good *Hydnum* in the early Friesian sense, and not in the least a *Grandinia* as Fries described that genus ("hymenium . . . papilloso-verrucosum"). According to Fries's own account of *Hydnum diaphanum* (Hym. Eur. 616. 1874), the present species cannot be the same as that fungus, to which Fries subordinated it. Bourdot bears witness (l.c. 1932) that his *Grandinia* is the same as material in Persoon's herbarium of *H. muscicola*. Bourdot's description, drawn up from more ample material than was available for the account here given, should be consulted for the range of variation of the species; most notably, he states that the fructification may be cream-color, in this agreeing with Persoon. There is no material at hand from which to verify the additional synonymy given in the Hyménomycètes de France.

4. TRECHISPORA SUBTRIGONOSPERMA (Rogers) Rogers & Jackson, Farlowia 1: 328. 1943. (FIG. 4)

*Sistotrema subtrigonospermum* Rogers, Univ. Iowa St. N. H. 17: 22. pl. 2, fig. 10. 1935.

(*Hypochnus asterophorus* sensu Rick, Brotéria sér. trim. Ciênc. Nat. 3: 151. 1934; sed vix *H. asterophorus* Bon. Handb. 160. fig. 256. 1851.

Fructification even, pruinose, when fresh barely waxy, grayish-white, drying to form a delicate bloom, under the binocular white, finely arachnoid; hyphae irregular, 3-5 (-8)  $\mu$  in diameter, with clamps throughout; basidia at first subglobose to ellipsoid, at maturity urniform, 12-18  $\mu$  long, 6  $\mu$  thick at the base, 4  $\mu$  at the neck of the prolongation, bearing 6 peripheral sterigmata

2.5  $\mu$  long; spores tetrahedral, attached at one of the points, 4.5–5  $\times$  3–4.5  $\mu$ .

On *Acer* sp., *Quercus* sp., and *Ulmus* sp.

Specimens have been examined from Brazil (*Rick*, some specimens as *H. asterophorus*), Jamaica, Ontario, Wisconsin, and Iowa.

Readily distinguished by the spores. In *Corticium trigonospermum* Bres. similar spores are attached by an apiculus arising on the middle of one side; from it the present species differs also in all other respects—basidia, mycelium, texture, and so on. Nor does the present fungus seem to be *Hypochnus asterophorus* ("bildet ein dichtes, faseriges Stratum . . . sternförmige Sporen"—Bonorden, l.c.). *Corticium fibrillosum* (Burt) Rogers & Jackson, *Farlowia* 1: 307. 1943, has spores not merely tetrahedral, but lobate and spinulose.

5. *Trechispora diademifera* (Bourd. & Galz.) comb. nov. (FIG. 5)

*Corticium diademiferum* Bourd. & Galz. Bull. Soc. Myc. Fr. 27: 244. 1911; Hym. Fr. 238. [1928]; Wakef. & Pears. Br. Myc. Soc. Tr. 8: 217. fig. 2. 1923.

*Corticium diademiferum* var. *perfuga* Bourd. & Galz. Hym. Fr. 238. [1928].

Fructification very thin, whitish, a pruinose or waxy-crustose film, closely adnate, when dry pruinose or vernicose; hyphae with clamps throughout, 1.5–5.5  $\mu$ , fairly distinct or (in dried material) sometimes completely disintegrated and invisible; in some hymenia contorted sterile bodies present among the basidia, 17–30  $\times$  4–6  $\mu$ , irregular in diameter, with hyaline content; basidia at first subglobose or short-pyriform, 6.5–8 (–13.5)  $\times$  5–7 (–10)  $\mu$ , developing a short apical prolongation, at maturity expanded at the summit, 9–27.5 (–31)  $\times$  4.5–8 (–9)  $\mu$ , bearing 6–8 peripheral recurved sterigmata 2–4 (–4.5)  $\mu$  long; spores obovate-subglobose or short-ellipsoid, abruptly attenuate at the base, 3–4.5 (–6)  $\times$  2–4 (–5)  $\mu$ .

American specimens on wood of *Picea sitchensis*, *Pinus contorta*, *P. Strobus*, *Pyrus Malus*, and *Quercus* sp., on leaves of *Populus tremuloides*, and on decaying fabricated trichomes of seeds of *Gossypium barbadense*.

Specimens have been examined from France (Allier, *Bourdot* 5700, FH-B), Panama, Ontario, Massachusetts, New York, Iowa, and Oregon.

Readily identified by the "subglobose" spores. The French specimen has fairly distinct hyphae and spores  $3-4 \times 2.5-3 \mu$ . A specimen collected by Pearson and determined by Bourdot is reported (Wakefield & Pearson, l.c.) likewise to have spores "ovate rather than subglobose." Six of the American specimens are almost identical, with collapsed hyphae and abundant spores  $3-3.5 \times 2-2.5 \mu$ . One of these is from the Oregon coast; two other collections from the same region are larger in all parts and have distinct hyphae. Since the authentic material cited, and a specimen from Nantucket, lie between these extremes, there appears no reasonable alternative to including all in the one species. The large specimens agree in most respects with the description of the var. *perfuga*.

6. TRECHISPORA CORONIFERA (Höhn. & Litsch.) Rogers & Jackson, Farlowia 1: 282. 1943. (FIG. 6)

*Gloeocystidium coroniferum* Höhn. & Litsch. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsab. 116, I: 825. 1907; Bourd. & Galz. Bull. Soc. Myc. Fr. 28: 370. [1913]; Hym. Fr. 264. [1928].

*Corticium coroniferum* (Höhn. & Litsch.) Sacc. & Trott. Syll. Fung. 21: 402. 1912; Wakef. & Pears. Br. Myc. Soc. Tr. 6: 139. (fig.) 1919.

*Corticium Atkinsonii* Burt, Mo. Bot. Gard. Ann. 13: 208. 1926.

Fructification when fresh very thin, waxy, pure white, under the binocular continuous or minutely granular, when dry whitish, adnate, under the binocular delicate reticulate-poroid; hyphae mostly distinct, (2-)  $3-7$  ( $-10.5$ )  $\mu$ , with clamps throughout, the basal long-celled, thick, sometimes filled with yellow refractive resinoid material, ampullate at the septa, not always well developed, the subbasidial more slender, abundantly branched; gloeocystidia (13-)  $20-100 \times (4.5-)$   $5-7$  ( $-9.5$ )  $\mu$ , elongate, obtuse, contorted, sometimes subcylindric, usually irregular, filled with yellow resinoid material; basidia when immature short-ellipsoid, forming a prolongation truncate-cylindric or slightly expanded at the summit,  $10-27.5 \times 5-7 \mu$ , bearing 6-8 slender peripheral sterigmata  $3-4 \mu$  long; spores oblong-ellipsoid to subcylindric, slightly depressed on the inside to curved,  $4.5-6 \times 2-3 \mu$ .

American material on undetermined conifer (?*Abies grandis*), *Acer* sp., *Populus grandidentata*, *P. tremuloides*, *Quercus* sp., and *Ulmus* sp.

Specimens have been examined from Austria (Bartberg bei Pressbaum, X.24.1906, *Höhnelt*, type of *G. coroniferum*, FH-H; and others), Ontario, Massachusetts, Vermont (Middlebury, 1896, *Burt*, as *Corticium arachnoideum*, FH-B; Battell Ledge, *Burt*, as *C. confine*, FH-B), New York (Ithaca, *Atkinson* 2558, type of *C. Atkinsonii*, FH-B), Louisiana (*Langlois* 246, paratype of *C. Atkinsonii*, FH-B), Iowa, and Oregon.

A form not notably differing from *T. Brinkmanni*, but here retained as a distinct species because it is distinguishable. The gloecystidia in the type are well developed, and many reach a length of 100  $\mu$ ; in none of the other specimens examined are they so large, although some are equally differentiated. In specimens with coarse basal mycelium having the same content as the gloecystidia the latter bodies may be difficult to detect; and a single specimen with highly developed gloecystidioid mycelium is included here even though it seems to possess no terminal hymenial bodies other than the basidia. It does not, however, seem possible to follow Bourdot (Hym. Fr. 237) in "assign[ing] to *G. coroniferum* those that exude in the trama an oily-resinous liquid"; most specimens of *T. Brinkmanni*, including the type of *C. coronilla* and the cited Brinkmann specimen of *O. Brinkmanni*, could be so described; calcium oxalate crystals may be present or lacking in them, as in the present species. As to *C. Atkinsonii*, it would be interesting to know what Burt saw in the Atkinson and Langlois specimens to compare with the dichophyses of *C. investiens*. The Altamount specimen which is the other paratype of *C. Atkinsonii* is sterile, and not *I. coronifera*.

#### 7. *Trechispora Sernanderi* (Litsch.) comb. nov. (FIG. 7)

*Gloeocystidium Sernanderi* Litsch. Svensk Bot. Tidskr. 25: 437. fig. 1. 1931.

Fructification widely effused, when dry creamy white (between Cartridge Buff and Ivory Yellow R) or white, farinose-membranaceous, thin, separable in fragments, under the binocular delicately hypochnoid, the margin narrow and paler, or wanting; hyphae distinct or mostly collapsed, with prominent clamps throughout, 3–6  $\mu$ , the subhymenial abundantly branched, the basal long-celled, in part yellow-guttulate and gloecystidioid, sometimes inflated up to 7–14  $\mu$ ; gloecystidia obtuse, subcylin-

dric, slightly expanded near the base or the middle, with yellow granular refractive content,  $80-107 \times 6-8 \mu$ , long emergent; occasional sterile basidia acute, long-conic, cystidioid; basidia in clusters, arising as ellipsoid or oblong bodies about  $6 \mu$  in diameter, developing an emergent slender-subcylindric apical prolongation, at maturity  $17-23 \times 5-6 \mu$ , bearing (2-) 4 divergent subulate sterigmata  $4.5-5 \mu$  long; spores ellipsoid oblong, straight or depressed on the inside, obtuse at the distal end, short-attenuate at the base,  $5.5-7 \times 3-3.5 \mu$ .

North American material on *Fagus grandifolia*; South American on an unidentified gymnosperm.

Specimens have been examined from Sweden (Vardsätra, I.11.30, *S. Lundell*, **paratype**, TRT; Stockholm, XII.9.94, *Romell*, det. Litschauer, TRT), Chile, and Ontario.

Distinguishable from all species other than *T. coronifera* by the gloecystidia, and from that species by the oblong rather than short-ellipsoid young basidia, by the slender, even basidial prolongation, by the sterigmata not more than four in number, and by the larger and straighter spores.

8. TRECHISPORA BRINKMANNI (Bres.) Rogers & Jackson, Farlowia 1: 288. 1943. (FIG. 8)

? *Corticium arachnoideum* Berk. Ann. Mag. Nat. Hist. 13: 345. pl. 9, fig. 3. 1844; nec *C. arachnoideum sensu* Burt, Mo. Bot. Gard. Ann. 13: 184. 1926; Bourd. & Galz. Hym. Fr. 197. [1928]; et auctt. plur.

? *Hypochnus coronatus* Bon. Hedwigia 15: 76. 1876; nec *H. coronatus* Schroet. in Cohn, Krypt.-Fl. Schles. 3(1): 418. 1888 (= *Pellicularia pruinata* (Bres.) Rogers; cf. Farlowia 1: 107. 1943).

*Odontia Brinkmanni* Bres. Ann. Myc. 1: 88. 1903; Bourd. & Galz. Bull. Soc. Myc. Fr. 27: 243. 1911; Donk, Nederl. Mycol. Ver. Med. 18-20: 139. 1931; Brown, Bot. Gaz. 96: 654. 1935.

*Corticium coronilla* Höhn. apud Höhn. & Litsch. Ann. Myc. 4: 291. (fig.). 1906; Bourd. & Galz. Bull. Soc. Myc. Fr. 27: 243. 1911; Hym. Fr. 236. [1928]; Donk, Nederl. Mycol. Ver. Med. 18-20: 137. 1931; Biggs, Mycologia 29: 686 et seq. fig. 21-26. 1937; Dodge, Mycologia 30: 133 et seq. fig. 1. 1938.

*Corticium octosporum* Schroet. ex Höhn. & Litsch. Ann. Myc. 4: 292. 1906; Bourd. & Galz. Bull. Soc. Myc. Fr. 27: 243. 1911;

Hym. Fr. 236. [1928]; Donk, Nederl. Mycol. Ver. Med. 18-20: 138. 1931.

? *Heptasporium gracile* Bref. Unters. 15: 111-116. pl. 5, fig. 1-10. 1912.

*Grandinia Brinkmanni* (Bres.) Bourd. & Galz. Bull. Soc. Myc. Fr. 30: 252. 1914; Hym. Fr. 410. [1928]; Wakef. & Pears. Br. Myc. Soc. Tr. 6: 74. (fig.). 1918; Miller, Mycologia 25: 360. pl. 43, fig. 3. 1933; Miller & Boyle, Univ. Iowa St. Nat. Hist. 18: 14. pl. 2, fig. 11. 1943.

*Corticium varians* Kniep, Zeits. Bot. 7: 372. fig. 6-11. pl. 2, fig. 1-6, 12, 14-17, 20. 1915.

*Sistotrema coronilla* (Höhn.) Donk ex Rogers, Univ. Iowa St. Nat. Hist. 17: 23. pl. 2, fig. 11. 1935.

(*Corticium alutaceum sensu* Lyman, Bost. Soc. Nat. Hist. Proc. 33: 160. pl. 19. 1907; nec *C. alutaceum* [Schrad.] ex Bres., Ac. Agiati Atti III 3: 110. 1897 (= *C. radiosum* (Fr. ex Pers.) Fr., Epicr. Syst. Myc. 560. 1838).

(*Corticium masculi* Sprau, Jahrb. Wiss. Bot. 85: 163. fig. 1-7. 1937, nomen nudum.

Fructification thin, even or minutely papillose, when fresh waxy-pruinose, waxy-farinose, farinose-arachnoid, or delicately membranous, grayish (when very thin), glaucous, or pure white, when dry pruinose and barely visible, vernicose, farinose, arachnoid, or rarely subpellicular or coarsely reticulate-fibrillose, white or rarely changing to yellowish (Massicot Yellow R); hyphae thin-walled, with large clamps throughout, the subicular 4-7  $\mu$  in diameter, straight- and long-celled, sometimes inflated at the septa to 9  $\mu$  (ampullate), often rare or wanting, the subhymenial short-celled, contorted, abundantly branched, (1.5-2-) about 4  $\mu$  in diameter, occasionally firm, usually collapsed, with contents often condensed into refractive resinoid masses, frequently interspersed with coarse crystalline material; basidia formed in clusters as the result of repeated proliferation from the subtending clamps, when immature subglobose to oblong, elongating by a cylindrical outgrowth truncate and more or less expanded at the summit (to 5.5  $\mu$ ), at maturity (7-) 10-24 (-27)  $\times$  (4-) 5-6 (-8)  $\mu$ , bearing about the periphery of the summit rarely 4 or 5, usually 6-8 recurved, capillary or subulate sterigmata 3-5  $\mu$  long; spores oblong-ellipsoid to subcylindric, straight or slightly depressed on the inside or very slightly curved, abruptly attenuate toward the apiculus, 3.5-7  $\times$  (1.5-) 2-3 (-4.5)  $\mu$ .



Imperfect stages: Some specimens develop, in nature or in culture, small brownish bulbils on the hymenium (cf. Biggs, and Lyman, ll. cc.); one (TRT 17325) shows below the hymenium abundant falcate fusoid bodies  $60-80 \times 7-8 \mu$ , 2-3-septate, with clamps, which appear to be conidial in function; Biggs reports the formation in culture of simple oidia.

American specimens on *Armillaria mellea*, *Ganoderma* sp., *Gloeotulasnella Pinicola*, *Hapalopilus gilvus*, *Peniophora* sp., *Piptoporus Betulinus*, on bark or wood of *Abies balsamea*, *Picea sitchensis*, *Pinus Strobus*, *Pinus* sp., *Pseudotsuga mucronata*, *Tsuga canadensis*, *Acer macrophyllum*, *A. rubrum*, *A. spicatum*, *Alnus oregana*, *A. tenuifolia*, *Arctostaphylos columbiana*, *Betula lutea*, *Betula* sp., *Carya ovata*, *Fagus grandifolia*, *Liquidambar styraciflua*, *Populus balsamifera*, *P. tremuloides*, *Pyrus Malus*, *Quercus Garryana*, *Q. macrocarpa*, *Quercus* spp., *Rhus* ? *glabra*, *Salix* spp., *Tilia americana*, *Ulmus americana*, *Vitis vulpina*, and on a pistillate rhachis of *Zea Mays*.

Specimens have been examined from Germany (Ollersdorferwald bei Rastatt, Schlesien, IV.24.77, *Schroeter*, type of *C. octosporum*, FH-H; Lengerich, Westfalen, IV.1905, *Brinkmann*, Westf. Pilze 112, as *O. Brinkmanni*, FH), Austria (Wiener Wald, Mödling, 1904, Höhnel, type of *C. coronilla*, FH-H; and others), England (*Berkeley*, as *C. arachnoideum*, perhaps type, FH), British Guiana, Panama, Nova Scotia, Ontario, Massachusetts, Rhode Island, New York, Virginia, North Carolina (Chapel Hill, *Couch* 4225, det. Burt as *C. incanum* Burt), Ohio, Tennessee, Iowa, Missouri, Idaho, and Oregon.

A collection of fungi exhibiting bewildering variability. Of all possible bases for subdivision of this complex, hymenial configuration is the most unnatural and the least usable in practice. As already noted by Bourdot, numerous specimens show both even and granulose areas; since the corticioid and grandinioid phases do not then characterize different individuals, they can scarcely justify separation into different genera and families—unless one should wish to dissect from the hymenia of his *Corticium* specimens fragments to be filed with his Hydnaceae. Furthermore, the type of *C. coronilla* and the cited Brinkmann specimen of *O. Brinkmanni* are completely indistinguishable

microscopically, and differ only in the slightly less delicate fructification of the latter and in the presence or absence of scattered granules. And finally, Biggs (l.c.) found a grandinoid tendency in more than one of the strains of this complex which she studied in culture.

The existence of occasional fructifications in which the hyphae do not collapse has suggested another possible basis for subdivision. Litschauer (litt. & specim.) and presumably Bourdot (1928) used regular mycelium, together with ellipsoid spores, to set off *C. octosporum* from *C. coronilla*. In the extensive material at hand, distinct and regular mycelium exists in combination with several sets of other characters; consequently, unless one is to be content to segregate on the basis of mycelium, disregarding texture, basidia, and spores, such a division cannot be maintained. The type of *C. coronilla* is (under the binocular, at a magnification of about 30X) minutely byssoid, with fimbriate margins; but the hyphae are almost completely collapsed, with irregular refractive masses in the distorted cells. The type of *C. octosporum* shows the uncollapsed mycelium that has been attributed to that species; but even so, the cells are short, irregular, and abundantly branched (as they are supposed to be rather in *C. coronilla*), and the fructification is so delicately pruinose as to be almost invisible. Furthermore, since specimens are at hand showing in the same preparation both rigid, straight-celled mycelium and collapsed, refractive, almost amorphous areas of disintegrating cells, the mycelium is apparently not only no basis for separation of *octosporum* from *coronilla*, but also of no great significance within the complex under discussion.

In different collections basidia differ in shape of the immature body (subglobose to oblong), in width of the base (compare fig. 21-23 of Biggs with her 24-25), in length of the prolongation, in degree of expansion of the summit, and in stoutness of the sterigmata. Spores differ greatly, not only in size, but also in form. Since both basidial and spore characters are quite constant within any one collection, it is probable that any future subdivision will have to rest on them. Even then, *C. coronilla* (with *O. Brinkmanni*) and *C. octosporum* must be kept together; in the type specimens the basidia are nearly identical in size

and form, and the spores of *octosporum* are only slightly longer and less rounded (*pace* Bourdot and Litschauer, according to whose treatments of these fungi the spores of *octosporum* should be ellipsoid, and therefore more rounded).

In 1937 Biggs published the results of an intensive study of *Corticium coronilla* (l.c.). On the grounds of constant differences shown in laboratory cultures she divided twenty-two collections, all but one from Ontario, and all but four from Lake Temagami, into four groups, of which one was further split into three subgroups. Her groups "differed from each other in general growth, presence or absence of asexual reproductive structures, ability to produce basidia in culture, and type of heterothallism." These cultural characters she then correlated, as far as possible, with characters of the parent collections as they were brought in from the field. From study of six additional collections she concluded that "the range in spore characters among these additional specimens must indicate the occurrence of yet other groups." These four groups studied in culture, according to Biggs, "differ from each other in profound and fundamental characters" and "represent distinct species"; presumably the same would be true of such other groups as remain less perfectly studied. Because of the difficulty of recognizing such species among the fungi as they occur in nature, because of the large number of species that would have to be recognized within "*Corticium coronilla*" to include the four described and the many undetected groups, and because of the difficulty of identifying any of her groups with established species, she chose, as a practical measure, to retain the single "collective species."

Dr. H. S. Jackson very generously offered the loan of the complete series of collections from which Biggs's cultures were derived, and I have examined them all and compared a representative of each of her groups with the types of *C. coronilla* and *C. octosporum* and the cited Brinkmann specimen of *O. Brinkmanni*. Her Group I is, as stated in her discussion, highly homogeneous. Group II is considerably less so, and is separable from Group I only by the spores, which are always flattened in Group I and, although variable in other respects, always depressed on the inside in Group II. The specimens included in Group III are

all somewhat pellicular and have their hyphae fairly distinct rather than collapsed; all have turned yellowish in the herbarium. The spores and basidia, however, are greatly variable, and one specimen has many gloeocystidioid hyphal segments. Group IV, which includes those specimens so delicate as to appear little more than a bloom to the naked eye, is quite homogeneous in other respects also; its spores are depressed, but proportionately shorter than those in Group II, and its immature basidia are more nearly globose. The type of *C. octosporum* would from its external characters belong to Group IV; its spores are those of Group III, and its basidia those of Group I or II. Externally and microscopically the type of *C. coronilla* would fall in Group I. Externally the Brinkmann specimen of *O. Brinkmanni* is a little more robust than most specimens of Group I, but might well be included there; microscopically, it is Group I.

When one has carefully noted the range of variation of these fungi it seems impossible to retain them all in a single species. After repeated and minute study of some hundred and fifty specimens, however, I can find no natural basis for segregation. The various sorts of characters—color, texture, mycelium, basidia, and spores—seem to show no correlation, but to exist in all possible combinations. Fructifications which are yellow, pellicular, and accompanied by bulbils, like her Group IIIb (and IIIc!) may differ considerably from Group III in microscopic characters. Specimens which appear to belong in Group IV may (like the type of *C. octosporum*) have spores more like those of Group III; and so on, *ad infinitum*. Briefly, it seems probable that a natural basis for subdivision will be found; but so far none has been detected.

There remains the question of the correct name for the species under discussion. *C. coronilla*, *C. octosporum*, and *O. Brinkmanni* are, as already implied, demonstrably the same. While Brefeld's characteristic aversion to the enumeration of definite characters makes it impossible to prove that *H. gracile* Bref. belongs here, it is just possible, if one is both imaginative and charitable, to develop from his turgid pages a sort of latent diagnosis for his culture-artifact, from which it may be inferred that the species can hardly belong anywhere else. Although Kniep does not

emphasize the form of the basidia in his species, *C. varians* probably belongs here also. *Hypochnus coronatus* Bon. can from its description belong nowhere but in *Trechispora*, and quite likely is the present species. There is, however, at least a possibility that it is some other species of the genus; and because *O. Brinkmanni* can have its characters better fixed, the uncertainty concerning *H. coronatus* is here recognized, and the later name used. As to *C. arachnoideum*: There are in the Farlow Herbarium two specimens from Berkeley of that species. One, in the Curtis collection, is a member of *Corticium* sect. *Pellicularia* Bourd. & Galz.; but unlike the *C. arachnoideum* of most authors, it has no clamps whatever (cf. Rogers & Jackson, *Farlowia* 1: 286. 1943). The other, in the general collections, is the present species. Both fungi are on the substratum originally noted for *C. arachnoideum*; either (or each) may be a portion of the type. Now Berkeley described the hymenium of his fungus as "consisting of elliptic sporophores arranged in little bunches"—not a bad description of the proliferating clusters of immature basidia seen in the present fungus, and well shown in the Berkeley specimen of it. In trying to match Berkeley's description later authors have apparently looked for elliptic spores rather than elliptic "sporophores"; the basidia of *C. arachnoideum* in the sense of most authors are not elliptic, but claviform. It seems therefore extremely probable that the correct name for the urnigera species under discussion must be derived from *C. arachnoideum* Berk.; it is desirable, however, to await word from Kew concerning the nature of Berkeley's no. 3974, designated by Massee (*Linn. Soc. Bot. Jour.* 27: 135. 1890) as the type—or, if that be a later collection, concerning whatever specimen demonstrably is the type—before adopting Berkeley's name. Meanwhile, Bresadola's specific epithet will serve.

9. *Trechispora Hirschii* (Donk) comb. nov. (FIG. 9)

*Corticium Hirschii* Donk, *Nederl. Mycol. Ver. Med.* 18-20: 139. 1931.

Fructification when fresh grayish, waxy-mucedinoid, when dry cinereous with a rosy tint (a little lighter than Pale Ecru-Drab R), thin crustose, closely adnate, under the binocular confluent, finely rimose with a few fibrils visible in the cracks, the areoles

with a minutely granular surface; mycelium distinct, with clamps throughout,  $2.5\text{--}4.5\ \mu$  in diameter, the basal long-celled and with walls somewhat thickened, the subhymenial thin-walled but rigid; basidia in small clusters (from proliferation of the subtending clamps) and also at various levels along the fertile hyphae, arising as evenly ellipsoid bodies about  $7 \times 5\ \mu$ , developing a cylindrical prolongation slightly expanded at the very summit, at maturity narrowly urniform,  $15\text{--}25 \times 4.5\text{--}5\text{--}(6)\ \mu$ , bearing 4 straight sterigmata  $2\text{--}3\ \mu$  long; spores evenly cylindric, strongly curved, especially toward the apiculus, obtuse,  $5\text{--}8 \times 2\text{--}2.5\ \mu$ .

On decorticate wood of *Populus grandidentata* and *Quercus Garryana*.

Specimens seen from Iowa and Oregon.

A species resembling *C. niveo-cremeum* in the production of basidia at various levels on the fertile hyphae, differing from it in the invariably narrow-urniform basidia, and from all remaining species of *Trechispora* in the strongly curved spores, the slightly thickened mycelial walls, and the pinkish-ashy color. As described by Donk, the fungus should have some spores larger ( $7\text{--}11 \times 2\text{--}4\ \mu$ ) and mycelium less well developed. Because of the variability of other species of the genus, it seems imprudent, in the absence of an authentic specimen of *C. Hirschii*, to attempt to segregate the material here described.

#### SPECIES EXCLUDENDAE

10. *CORTICIUM NIVEO-CREMEUM* Höhn. & Litsch. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsab. **117**, I: 1117. 1908; Bourd. & Galz. Bull. Soc. Myc. Fr. **27**: 244. 1911; Hym. Fr. 237. fig. 72. [1928]; Wakef. & Pears. Br. Myc. Soc. Tr. **6**: 71. (fig.) 1918; Kühner, Le Botaniste **17**: 32. fig. 9. 1926; Donk, Nederl. Mycol. Ver. Med. **18--20**: 138. 1931. (FIG. 10)

(*Corticium niveo-cremeum* Höhn. & Litsch., Wiesner-Festschr.

65. 1908 (nomen nudum).

Fructification thin, adnate, waxy, pruinose or crustose, whitish, when dry pruinose to crustose, under the lens poroid-reticulate to subcontinuous, rimose, the elements conglutinate to form a shining film over the surface, whitish or sordid-whitish to brownish where bruised; hyphae distinct, with clamps throughout,  $2\text{--}5\ \mu$  in diameter; basidia in small loose clusters formed through

the proliferation of the subtending clamps, and also arising at various levels on the fertile hyphae, at first ellipsoid-obovate to obpyriform, about  $12 \times 7 \mu$ , sometimes with a narrow stipe up to  $20 \mu$  long, at maturity broadly clavate to subcylindric, sometimes distinctly constricted, but at no stage composed of broad basal vesicle and narrow prolongation, variable in length, (12.5–)  $18-42 \times (5-)$   $6-8 \mu$ , bearing 4–8 peripheral sterigmata  $4-4.5 \mu$  long; spores obtuse, cylindric, straight or only slightly curved, (5.5–)  $7-9.5 \times (2.5-)$   $3-3.5 \mu$ .

American specimens on *Abies balsamea*, ? *Fagus grandifolia*, *Quercus* sp., and unidentified hardwoods.

Material has been examined from Austria (Saagberg, Wienerwald, III.11.1905, *Höhnelt*, **type**, FH-H), Netherlands, France, Ontario, Massachusetts, Rhode Island, Pennsylvania, Iowa, and Missouri.

Strongly resembling *urnigera* species in the clusters of obovate immature basidia, in possession of more than four sterigmata, and in basidia sometimes constricted (and therefore apparently urniform and with expanded prolongation). The development of these basidia seems, however, not to be that of the *urnigera* type—not to pass through stages of (1) inflated basal vesicle, (2) narrow subcylindric prolongation, and (3) apical expansion—and *C. niveo-cremeum* seems not to be closely related to such species as *T. Brinkmanni*. Of *C. niveo-cremeum* Bourdot wrote (Bull. Soc. Myc. Fr. 27: 243. 1911), “a well developed species which departs somewhat from the type of this group [*Urnigera*].” It is recognizable among the species with more than four sterigmata by the origin of basidia at various heights and variability in their length, and by large spores and basidia.

11. *CORTICIUM SUBCICUM* Litsch. apud Lundell & Nannfelt, Fung. Exs. Suec. 464. 1937; Svensk Bot. Tidskr. 32: 286. 1938; Rogers & Jackson, Farlowia 1: 285. 1943. (FIG. 11)

? *Thelephora illinita* Wallr. Fl. Crypt. Germ. 2: 564. 1833.

*Corticium calceum sensu* Bourd. & Galz. Hym. Fr. 237. [1928]; Donk, Nederl. Mycol. Ver. Med. 18–20: 137. 1931; Bourd. Bull. Soc. Myc. Fr. 48: 211. 1932; nec *C. calceum* (Pers.) Fr. Epicr. Syst. Myc. 562. 1838 (= *Sebacina calcea* (Pers.) Bres. Fung. Trid. 2: 64. 1898); nec *C. calceum* “Fr. emend. Romell & Burt” in Burt, Mo. Bot. Gard. Ann. 13: 203. 1926 (nomen confusum).

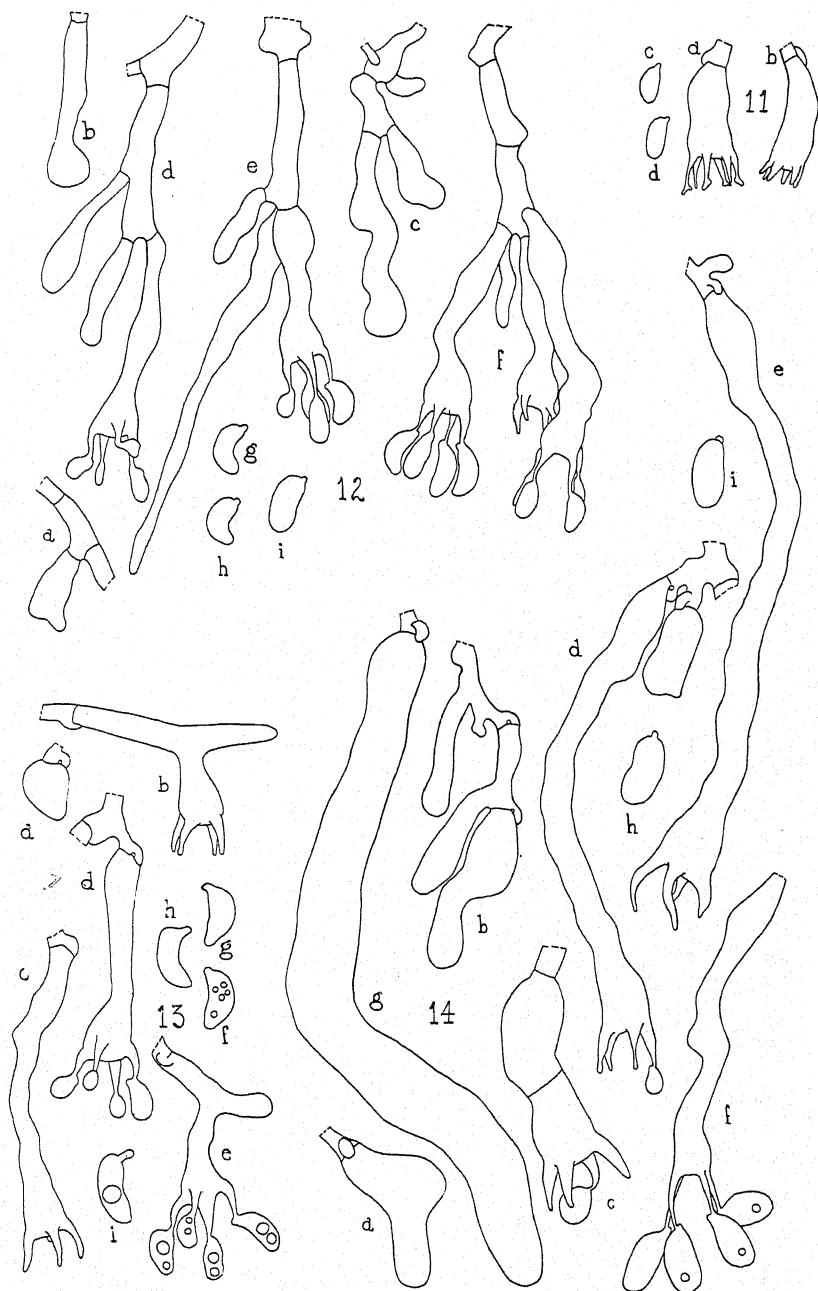


FIG. 11. *Corticium suecicum*; 12, *Galzinia cymosa*; 13, *G. pedicellata*; 14, *G. occidentalis*.



Fructification adnate, at first grayish, waxy-pruinose, soon pure white, waxy-crustose, not coherent, even or tuberculose, when dry crustose-membranaceous, the surface a little glazed, creamy whitish, continuous or reticulate-poroid or abundantly rimose, separable only in mealy flakes; hyphae thin-walled, with clamps throughout,  $2-5$  ( $-7$ )  $\mu$  in diameter, with some inflated segments, at first distinct but in mature fructifications mostly collapsed; basidia clavate, abruptly tapered toward the base,  $15-25 \times 5-7 \mu$ , subtended by proliferating clamps, bearing about the obtuse or somewhat truncate summit 6 slender-subulate sterigmata  $3.5-4.5 \mu$  long; spores even, with wall slightly thickened and refractive, oblong, sometimes a little depressed on the inside,  $(4-)$   $5-7$  ( $-8$ )  $\times 2.5-3.5 \mu$ .

American specimens on wood of *Abies balsamea*, *Picea* sp., *Pinus Strobus*, *Pseudotsuga mucronata*, *Thuja occidentalis*, *Acer saccharum*, *Alnus oregana*, and *Castanea dentata*.

Specimens have been examined from Sweden (Bygget, 1909, *C. G. Lloyd 09,128*, det. Bourdot as *C. calceum*, **paratype**, BPI), Ontario, Massachusetts, New York (*C. H. Peck 9, 20*; *G. F. Atkinson 941*, all det. Burt as *C. calceum*, FH-B), Ohio, Oregon.

A species resembling the *Urnigera* fungi in the origin of basidia from proliferative clamps and in the regular occurrence of six sterigmata to the basidium. Its basidia do not, however, pass through any of the developmental stages characteristic of *Trechispora*, nor are they ever urniform at maturity. Readily recognized by the claviform basidia, which in dried collections are especially apt to become imperfectly stainable, to collapse at the summit so as to become sharply truncate, and to retain, on almost invisible sterigmata, the cluster of six immature spores—and, of course, even more readily recognized by the number of sterigmata.

For further discussion of the history of *C. calceum* notes by Donk (l.c.) and Rogers & Jackson (*Farlowia* 1: 284. 1943) may be consulted. *Thelephora illinita* Wallr. may well be the present species, but may equally well be *Peniophora gracillima* Ellis & Ev. ex Rogers & Jackson, *Farlowia* 1: 317. 1943, or, like *P. glebulosa* (Fr.) Sacc. & Syd., a combination of two fungi. Since it is quite impossible to make a reliable guess where Wallroth's name must apply, it seems best not to attempt to revive it. Since *C. suecicum* is a new name for *C. calceum* sensu Bourd. & Galz., the

Lloyd specimen which they cite is a paratype, and was used to make certain the application of Litschauer's name.

*Corticium suecicum* is here discussed because it was referred by Bourdot & Galzin to *Corticium* sect. *Urnigera* and by Bondarzew & Singer, without renaming, to *Sistotrema*—and because its six-sterigmate basidia may lead mycologists to seek it in *Trechispora*.

TRECHISPORA CANDIDISSIMA (Schw.) Bond. & Sing. Ann. Myc.  
39: 48. 1941.

TRECHISPORA TRACHYSPORA (Bourd. & Galz.) Bond. & Sing. Ann.  
Myc. 39: 48. 1941.

These two species, treated by Bourdot & Galzin in *Poria* [sect.] *Subtiles* (Hym. Fr. 656. [1928]), were transferred to *Trechispora* through misunderstanding of the characters of *T. onusta*. See p. 80 of this paper.

GALZINIA Bourdot, Assoc. Fr. Av. Sc. 45: 577. [1922]; Bourd. & Galz. Hym. Fr. 339. [1928].

Type: *G. pedicellata* Bourd.

Fructification resupinate, waxy-pruinose to mucous; basidia arising in loose clusters as vesicular bodies, developing a slender neck of variable and often great length and an inflated apical portion bearing 4 sterigmata; spores not germinating by repetition.

*Galzinia* differs from *Trechispora* in the consistency of the fructification, in the loosely clustered and often short-stalked immature basidia, in the variable and often extremely long basidial prolongation and its origin from either the end or the side of the basal vesicle, in the regular presence of only four sterigmata, and in other respects less readily described.

The position of the genus is uncertain. In his original description Bourdot assigned it a place near *Vuilleminia*, and it follows that genus in the Hyménomycètes de France. *Vuilleminia* is, however, probably not distinct from *Aleurodiscus*, and it seems unlikely that *Galzinia* is closely related to either. Bourdot commented also on the similarity of the shorter basidia of *Galzinia* to the urnigera type, to which their resemblance can be no more than superficial. It seems safe to leave the genus for the present in that great miscellany, the Thelephoraceae.

## KEY TO THE SPECIES

1. Hyphae without clamps; spores about  $7 \times 3 \mu$  ..... 1. *G. cymosa*.
1. Hyphae with clamps; spores larger ..... 2
  2. Fructification mucous; spores  $8-11 \times 3-4.5 \mu$ ; gloeocystidia absent ..... 2. *G. pedicellata*.
  2. Fructification waxy-pruinose; spores  $10-12.5 \times 4.5-5 \mu$ ; gloeocystidia present ..... 3. *G. occidentalis*.

1. *Galzinia cymosa* sp. nov.<sup>5</sup> (FIG. 12)

Fructification when fresh mucous-gelatinous, even or (in spots) granulose, of appreciable thickness, plumbeous (Light Quaker Drab R), when dry forming a barely perceptible dull vernicose film or entirely evanescent; all elements of the fructification embedded in gelatinous material and apparently contributing to it by gelatinization of their walls; hyphae without clamps, distinctly articulate,  $1.5-4 \mu$  in diameter, pseudo-dichotomous, the wall nearly or quite invisible, many segments with the distal end considerably expanded; filiform hyphal bodies arising among the basidia; basidia arising as irregularly claviform or narrow-ovoid bodies, producing a tubular outgrowth of uneven diameter and varied length, and at its summit abruptly expanded into a vesicle at first subglobose, later truncate, the whole  $18-38 \times 6-7 \mu$ , bearing (3-) 4 slightly divergent subulate sterigmata  $4.5-6 \mu$  long; spores curved, tapered toward both ends, obtuse,  $6.5-7 (-7.5) \times 3 (-4) \mu$ .

On firm wood of a fallen log of *Pinus rigida*.

Specimen examined: Massachusetts: woods east of Watershops Pond, Springfield, VIII.17.43, D. P. Rogers 1026, type.

The fructification, spread out for a length of over 7 dm. on the side of the log, was superficially indistinguishable from a vigorous growth of such Tremellales as *Helicogloea Lagerheimi*, *Sebacina podlachica*, and *Gloeotulasnella traumatica*. The peculiar method of branching, by which a hyphal cell gives rise at its distal end to a number of branches, paraphysoid bodies, or basidia, and after their disintegration may retain the scars of their bases, is quite like that shown in a number of Auriculariaceae, notably

<sup>5</sup> Fructificatio viva mucoso-gelatinosa, plumbea, sicca evanescens; hyphae zygodematibus carentes,  $1.5-4 \mu$  diam., articulatae, frequenter pseudo-dichotomae, tenuissime tunicatae; basidia primo claviformia vel anguste ovata, tubulum inaequalem et longitudine varium gignentia, in vesiculum subglobosum ad apicem expansa, matura  $18-38 \times 6-7 \mu$ , sterigmata (3-) 4 subuliformia,  $4.5-6 \mu$  longit., ferentia; sporae curvulae, ad apices ambos attenuatae, obtusae, plurimae  $7 \times 3 \mu$ .

*H. Lagerheimi*, differing, however, in the larger number of branches often present. The effect of dichotomy is given when the first branch and the prolongation of the parent hypha are of the same size, and also when a pair of branches develop more rapidly than the main axis lying between them. The method of branching gives the present species a microscopic appearance strikingly different from that of the other species of *Galzinia*, and the immature basidia differ greatly in form. The similarities in texture, in basidia, and (probably only by coincidence) in spores are sufficient to justify the assignment of this species to *Galzinia* rather than to a genus of its own.

2. *GALZINIA PEDICELLATA* Bourdot, Assoc. Fr. Av. Sc. 45: 577. [1922]; Bourd. & Galz. Hym. Fr. 340. fig. 106. [1928]. (FIG. 13)

Fructification when fresh mucous, slightly pruinose, granulose under the binocular, very thin to fairly thick, when dry vernicose, subhyaline, except under considerable magnification completely invisible; hyphae with walls very thin (probably partly gelatinized), irregularly branched, with clamps throughout, 2–4  $\mu$  in diameter, irregularly inflated to 7.5  $\mu$ ; basidia in loose clusters, mostly on short stalks from which they are separated by a clamp, at first ellipsoid or pyriform, 8–11  $\times$  6.5–7  $\mu$ , forming from the apex or one side of this primary vesicle a prolongation 2.5–3  $\mu$  in diameter, of variable length, at maturity strongly inflated at the summit to 6–7  $\mu$ , the base sometimes partly shrunken, 4.5–5  $\mu$ , the whole 18–45  $\mu$  long, bearing apically 4 stout divergent sterigmata 3.5–5  $\mu$  long; spores curved subcylindric, of even diameter or widest near the apiculus, 8–11  $\times$  3–4.5  $\mu$ , germinating on the hymenium without formation of secondary spores.

On partly decayed logs of *Pinus contorta* and *P. pungens*; only on bare wood.

Two specimens seen, from Pennsylvania and Oregon.

The Oregon specimen of *G. pedicellata* shows all the variations in basidial form figured in Bourdot's excellent illustrations and a number of others even more bizarre. The neck which joins the primary vesicle to the summit is not, however, as narrow as there shown (described as 1.5–2  $\mu$ ); this discrepancy is probably the result of the employment of different techniques for expanding collapsed material, rather than of difference in the fungus

itself. The thinner specimen, from Oregon, shows most basidia with the apical part arising from the side of the basal; in the thicker and less fertile Pennsylvania specimen the basidia are mostly straight rather than geniculate.

3. *Galzinia occidentalis* sp. nov.<sup>6</sup> (FIG. 14)

Fructification thin, when fresh whitish pruinose, under the lens waxy-hypochnoid, when dry vernicose-pruinose, under the lens visibly composed of conglutinate whitish hyphae, and somewhat frost-like in appearance, or in thinner areas merely vernicose; mycelium with clamps throughout, 2-4  $\mu$  in diameter, partly collapsed, irregularly branched; gloeocystidia arising among the basidia, thin-walled, colorless, with stainable content, finally empty, irregularly filiform, clavate, somewhat ventricose, or sub-cylindric, obtuse, 56-125  $\times$  6-11.5  $\mu$ ; basidia in irregular clusters or borne in series along the fertile hyphae, at first ovate, ellipsoid, or oblong, 11.5-16  $\times$  7-9  $\mu$ , developing an apical or lateral prolongation 4.5-5  $\mu$  in diameter above the basal vesicle, of variable length, finally strongly expanded to (6-) 7-9  $\mu$  at the summit, the whole basidium 23-53 (-100)  $\times$  6-9  $\mu$ , bearing 4 stout, strongly divergent sterigmata 7  $\times$  1.5-2  $\mu$ ; spores subcylindric, obtuse at both ends, very slightly curved or straight, (9-) 10-12.5  $\times$  4.5-5 (-6)  $\mu$ , frequently germinating on the hymenium by a hypha.

On wood of *Pinus contorta* and *Pseudotsuga mucronata*.

Specimens examined: Oregon: near Lebanon, Linn Co., IV.9. 1937, D. P. Rogers 371, **type**; Sutton L., near Florence, XI.26. 1937, A. M. & D. P. Rogers 431.

Distinct from *G. pedicellata* in the larger size of all organs, the straight, obtuse spores of even diameter, the relatively much thicker necks of the basidia, and the texture; even more surely distinguished by the gloeocystidia, which may, however, be hard to find. *Galzinia occidentalis* is, chiefly because of its texture, a species less distinctive among the lower basidiomycetes than

<sup>6</sup> Fructificatio tenuis, albo-pruinosa, sub lente ceraceo-hypochnoidea, sicca e hyphis conglutinatiss operte constituta, vel ceracea; hyphae nodoso-septatae, 2-4  $\mu$  in diam.; gloeocystidia hyalina, irregulariter subcylindracea vel linearia, obtusa, 56-125  $\times$  6-11.5  $\mu$ ; basidia in fasciculis aggregata vel seriatim et separatim ordinata, primo ellipsoidea, oblonga, vel ovata, 11.5-16  $\times$  7-9  $\mu$ , per appendicem longit. variabilem, diam. 4.5-5  $\mu$ , producta, matura 25-53 (-100)  $\times$  6-9  $\mu$ , ad apicem usque ad (6-) 7-9  $\mu$  inflata, sterigmata 4 crassa, 7  $\times$  1.5-2  $\mu$ , gerentia; spora cylindracea, nonnumquam leviter curvulae, utrinque obtusae, (9-) 10-12.5  $\times$  4.5-5 (-6)  $\mu$ .

its congeners, but there seems no reason to hesitate in assigning it to *Galzinia*. Basidia  $100\ \mu$  long were recorded when the fresh material was studied; none of this size have persisted after drying.

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#### EXPLANATION OF FIGURES

All figures were drawn from KOH-phloxine preparations with camera lucida at  $2000\times$  and reduced in reproduction to  $1000\times$ . FIG. 1, *Trechispora onusta*: a-c, type; d-h, Bresadola 86. FIG. 2, *Trechispora Raduloides*: Martin 4871. FIG. 3, *Trechispora muscicola*: Bourdot 15202 (f, g, ampulliform clamps). FIG. 4, *Trechispora subtrigonosperma*: type (c, spore in profile; d, spore in face view). FIG. 5, *Trechispora diademifera*: a-e, D. P. R. 1004; f-h, D. P. R. 1001. FIG. 6, *Trechispora coronifera*: a-d, D. P. R. 1000; e-g, type (d, g, gloeocystidia). FIG. 7, *Trechispora Sernanderi*: paratype (a, one sterile and two immature basidia; d, gloeocystidium). FIG. 8, *T. Brinkmanni*: a-d, D. P. R. 1007; e-i, D. P. R. 1009. FIG. 9, *Trechispora Hirschii*: D. P. R. 963. FIG. 10, *Corticium niveo-cremeum*: a, b, D. P. R. 1014; c-e, D. P. R. 1016. FIG. 11, *Corticium suecicum*: TRT 8489. FIG. 12, *Galzinia cymosa*: type (e, with paraphysoid body). FIG. 13, *Galzinia pedicellata*: D. P. R. 444 (g-i, spores germinating on the hymenium). FIG. 14, *Galzinia occidentalis*: type (g, gloeocystidium).

# STUDIES IN NORTH AMERICAN RUSSULAE

GERTRUDE S. BURLINGHAM

(WITH 2 FIGURES)

First, what characteristics should be used in distinguishing species? All will probably agree with the specific importance of those gross structures of pileus, stipe and lamellae upon which Elias Fries based his separation of species in *Hymenomycetes Europaei*. Since that time the value of exact spore color as seen in a fresh dense spore print, and the spore ornamentation as brought out with iodine solution under a high power magnification have come to be known. How much importance should be put upon chemical composition and chemical reactions? Certainly if the reactions of certain chemical reagents are to be used in distinguishing species, the *natural* chemical content of a species must be given equal value in determining a species. Take as example the *acid taste* of the context. I have found this to be constant in a species at the same stage of development unless washed out by rains. In some species the acidity may be found only in the young, perhaps only when tasted fresh in the field. It may be present in the cuticle only, or in the lamellae or throughout the context. But wherever it may be, it will always be found in the same stage and structure when tested in fresh specimens in the field unless, as previously stated, rains may have rendered them water soaked or have washed out the taste, especially in the cuticle. The importance of tasting all parts and stages of fresh specimens in the field has often been overlooked or neglected.

Also the *odor* in both fresh specimens and of those drying is of equal importance. Since this sometimes develops only with age or in drying and does not persist in the dried specimens, one must be familiar with species in both conditions. One who proposes to describe species in this genus must also have a keen sense of smell! Had Elias Fries been able to detect the odor of *Russula xerampelina* there would have been less confusion regarding that

species. Odor like the taste of a species is due to some chemical content and therefore should be considered a factor in separating species.

While among the red *Russulae* there is considerable variation of color in a species, nevertheless there is a certain limitation in this variation, so that as a whole it may be taken into consideration. Any change in color in the broken flesh or with age or in drying may be considered as chemical in nature due perhaps to some oxidizing ferment as in the *Lactariae*. The rapidity of this change may depend upon the age of the plant, but careful observation will detect it.

Therefore these three characteristics, taste, odor, and color changes, must be given equal importance with gross structural characters in the distinction of species.

Concerning the shape, size and ornamentation of spores, the first essential is a good authentic spore print. And in case of an undescribed species it is well to label the specimen from which the print was made. Unless species are kept separate in collecting and in drying there may be spores from other species on the lamellae. If sufficient precaution is taken the variation in the pattern of the spores will be due to difference in maturity or in position. By this I do not mean that any two spores will be identical in markings, but the general pattern will be the same, not varying from one extreme to another. By taking spores from a print there will be less danger of having immature spores under observation. In closely related species in a group there may be a resemblance in pattern, but still a difference. Crawshay's method of showing several spores with the description on the same page at one side is excellent<sup>1</sup> as it renders easy and quick comparison, thus aiding in the determination of the species at hand.

In Mycologia 34: 66. 1942, and 35: 142. 1943, Dr. Rolf Singer has taken up in some detail type studies of some of the *Russulae* described from the United States. While with many of his conclusions I can agree, concerning others I must differ. In his study of *Russula dura* Burl. he was correct in considering it near if not the same as *Russula ochroleucoides* Kauff. From

<sup>1</sup> Spore ornamentation of the Russulas, R. Crawshay.



the first collection in 1921 except for one small specimen I did not find the species again until August 1939 when it occurred in some quantity in woods about one-half mile from the type collection. Upon comparing it with a type specimen of *Russula ochroleucoides* I found it to be the same as that species and therefore *Russula dura* becomes a synonym of that species. It should be noted that the taste is first sweetish, then bitterish, unpleasant, aromatic and cooling. The odor is detected as a flavor in tasting rather than by smelling the mushroom.

In Mycologia 31: 497. 1939 I gave the new name *Russula insignita* to *Russula insignis* Burl. since the name had been used by Quélet for another species, adding also further notes and spore drawings to show the ornamentation. However shortly before the publication of this Dr. Singer had given it the name of *R. Burlinghamiae*.

While *Russula blanda* Burl. is known only from the type locality, it was collected on July 23 and 27, 1912, and again on September 18, 1915. From *Russula lactea* Fr. it differs in its fragile texture, white spores, thin, close, slightly decurrent lamellae. It therefore belongs in a different group than the European *Russula lactea*. The spore ornamentation was shown in figure 5, Mycologia 31: 491. 1939, with the description on page 498.

Since the spores of *Russula pulchra* Burl. and *Russula perplexa* Burl. have not been shown with their ornamentation they are illustrated in figures 1, *a* and *b*. Those of the former are on the average  $7.5 \times 8.75 \mu$  exclusive of the apiculus. Under the 1/6 power they appear very echinulate and the protuberances are not all of the same length. They seem uniguttulate or duoguttulate. With iodine and the oil immersion lens fine lines are seen connecting some of the protuberances. The spores of *Russula perplexa* vary from  $7.5 \times 8.75 \mu$  to  $8 \times 9 \mu$  exclusive of the apiculus. The protuberances are visible under the 1/6 power and also vary in size. With iodine very fine lines appear connecting some of these. The color in a fresh spore print is white. Even now 27 years later the color is fleshy-white tone 1. Mr. Davis described the color of fresh spores of *Russula pulchra* as "just off

white." Now the print is flesh color 67 tone 2, slightly darker than the cream white of the fresh print.

*Russula sulcatipes* Murrill can scarcely be a form of *Russula Mariae* Peck since the stipe is milk white and glabrous while that of the latter is usually at least through the central part concolorous with the pileus and adorned with glandular-like dots. When it is rarely white it still has the same surface covering, appearing pruinose under less magnification. The cut flesh of *Russula Mariae* has a slight but characteristic odor and is somewhat sticky. The spores are very characteristic both in the globose shape and banded appearance. Although spore drawings were shown in figure 6 B, *Mycologia* 28: 265. 1936, another drawing is shown in figure 1, c showing the contrast with the spores of *Russula sulcatipes*, fig. 1, d. The spores from which this figure was made were taken from type material. They are not globose unless viewed on end and have tuberculate protuberances of different sizes. When the iodine stain has been washed out the tubercles and faint fine lines connecting many of them remain in blue. I find the size to vary from 6.87 to 7.5  $\mu$   $\times$  8-10  $\mu$ .

In *Mycologia* 28: 265. 1936 I reported *Russula vesca* from Oregon, and called attention to the fact that *Russula brunneola* Burl. was a synonym of that species. It occurs abundantly in Vermont, and had the species not been included by Fries with the *Heterophyllae* in all of his Latin publications it would undoubtedly have been reported from various states. From *Russula vesca* Fries *Russula flocculosa* Burl. differs not only in the distant lamellae and spore ornamentation but in the absence of the radiating veins and rugose condition of the surface of the pileus. The floccose almost tomentose condition of the surface of the pileus remains even at maturity. The spore ornamentation was shown in figure 6, *Mycologia* 31: 491. 1939.

In *Russula Davisii* Burl. we find gross structural characteristics separating it from *Russula olivacea* (Schaeff.) Fries. If we accept Fries's description of the species, the surface of the pileus is silky and squamulose, the margin even, and the color varies from sordid purple to olivaceous or entirely fuscous-olivaceous, while the lamellae have shorter intermixed with forking ones, and the

flesh changes to yellow. In *Russula Davisii* the pileus is pruinose to glabrous with the margin striate-tuberculate, and the lamellae are equal, forking at the stipe and inclined to be decurrent. Mr. Davis described the flesh as white and white under the cuticle, and since he was a careful observer I believe he would have discovered if the flesh had changed to yellow. In fact where the cuticle had been removed the flesh does not show any more change than the normal drying of white flesh would show. He described the color as Pinard yellow (R). There is no trace of purple or olivaceous in any of the specimens. Regarding the stipe he wrote in his field notes, "Stem has not discolored enough to write about." In the dried specimens the stipe does show a slight discoloration. He gave the spore color yellow ochre rather than ochraceous and the print now is only yellow ochre 326 tone 2. The pattern differs according to position as the figure shows (FIG. 1, e). The spores are not globose except when viewed more or less on end. Dr. Kauffman in his *Agaricaceae* of Michigan, p. 145, calls attention to the fact that in Europe *Russula olivacea* is a debated species. Hence is it not best to adhere to the description given by Fries of unequal lamellae and silky-squamulose pileus with which gross characters *Russula Davisii* does not agree, and for the present consider this a valid species? The type is number 1 Aug. 7—1916—Davis. It may be well here to state that in collecting Mr. Davis limited himself in any one trip to the few species which he could carefully study in the fresh condition.

It is difficult to consider *Russula Murrillii* Burl. identical with *Russula punctata* Krombh. to which Singer refers it. According to the description by Krombholz the surface of the pileus is glabrous, viscid, shining, with the margin sulcate. From this *Russula Murrillii* differs in a pruinose surface becoming pruinose-floccose, a dull appearance and even margin. Krombholz describes the stipe of his species as slightly enlarged at the base, white or white becoming yellowish while that of *Russula Murrillii* is chalk white and unchanging in drying and equal. The context of the latter is thin while the pileus of *R. punctata* is described as thick. As to whether *Russula punctata* Krombh. is synonymous with *Russula amethystina* Quél., in the absence of exsiccati

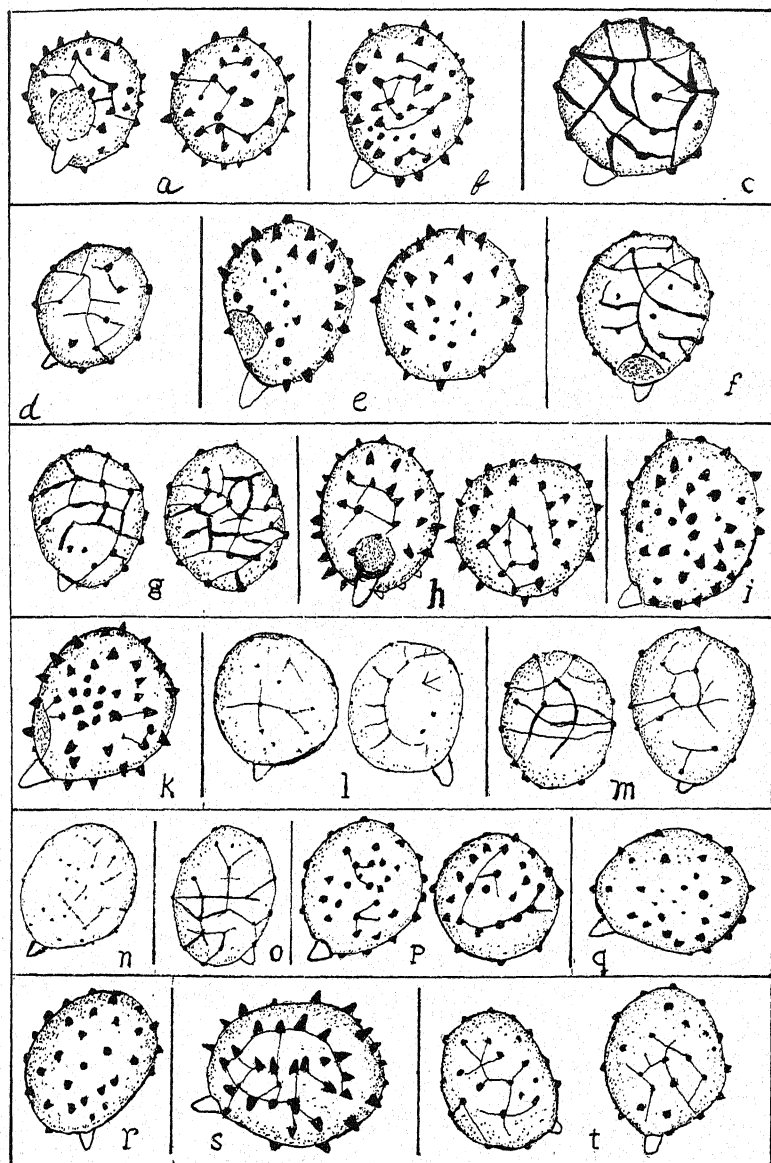


FIG. 1. a, *R. pulchra*; b, *R. perplexa*; c, *R. Mariae*; d, *R. sulcatipes*; e, *R. Davisii*; f, *R. Murrillii*; g, *R. mordax*; h, *R. squalida*; i, *R. serissima*; k, *R. fucosa*; l, *R. cinerascens*; m, *R. Burkei*; n, *R. magnifica*; o, *R. polyphylla*; p, *R. flaviceps*; q, *R. variata*; r, *R. simulans*; s, *R. praeumbonata*; t, *R. vesicatoria*.

of types, the original description must decide. Quélet describes the stipe of his species as narrowed at the base, pruinose and white in contrast with the thickened base and white to yellowish of that in *R. punctata*. He describes the pileus as mealy with white tender sweet slightly fragrant flesh, and the lamellae as adnate, jonquil then primrose colored. Krombholz gives the lamellae of *R. punctata* as *free*, distant and *ochraceous*. The color of his illustration does not resemble the description of the color of Quélet's species. Julius Schaeffer gives the color of the spores of his interpretation of *R. amethystina* as ochre. The spores of *Russula Murrillii* are pale yellow and are more egg shaped than those of *R. amethystina* shown by Julius Schaeffer. They have blunt tubercle-like protuberances connected by lines (FIG. 1, f). Until further collections of this species reveal taste and odor and furnish a satisfactory spore print, it is best to retain the name *Russula Murrillii*.

*Russula mordax* Burl. is separated from *Russula badia* Quél. first by the chemical qualities which render it instantly peppery and by the lack of odor. Regarding the taste of *R. badia*, both Singer and Schaeffer describe it as first *mild*. Schaeffer writes, taste long evidently mild, after a longer time, often a minute, intolerably sharp and persisting. Regarding the odor he says, one with a good nose need not burn the tongue. Hence it would have been probable that the odor would have been detected since I am on the lookout for the odor of any species. Quélet describes the color of the spores as citrine which is much brighter and lighter yellow than either Singer or Schaeffer note, and brighter than the color of the spores of *Russula mordax*. Fifteen years after collecting, the spore print remains ochroleucous. The spores are also smaller and the spines while connected are not so much in ridges as shown in the spores of *R. badia*, Table 27, 8-e of Schaeffer's Monographie. Quélet states that *Russula badia* resembles *Russula xerampelina*. This is not true regarding *Russula mordax*. Until further collections reveal that this species has an odor (*douce* Quél.) and a mild taste preceding the acidity, sinuate lamellae and larger spores it would seem better to retain *Russula mordax* as a distinct species. Spores are shown in figure 1, g.

The *xerampelina* group of *Russulae* is at present one of the most puzzling. Singer and Schaeffer put under one species all of those having the characteristic fishy odor regardless of acidity, color of lamellae and spores, and spore pattern. Julius Schaeffer in his *Russula* Monograph, p. 373, states that occasionally the young lamellae of *Russula xerampelina* are somewhat sharp to sharp, soon fully mild (Junge Lam. gelegentlich schärflich bis scharf, bald völlig mild) and the pattern of the spores variable according to variety (Im Relief variabel nach den varietäten). The first step to be taken in solving the puzzle is to ascertain if the young lamellae of the *Russula xerampelina* of Fries are peppery.

We have growing in spruce woods in Vermont and as Kauffman reported in coniferous woods in Michigan the typical *Russula xerampelina* Fries with the reddish stipe and the same coloration of the pileus as that which I saw growing in Sweden. Kauffman considered *Russula squalida* Peck as having less firm consistency and a white stipe: "Hundreds of individuals were examined about Ann Arbor and all had white stems, never red."<sup>2</sup> Peck also described the stipe as white and equal, while that of *R. xerampelina* is not only more or less reddish but is club shaped. The spores of *R. squalida* are smaller, varying from  $7-8.75 \mu \times 8.75-10 \mu$ . They are echinulate with fine lines connecting the base of the echinules occasionally. These are difficult to see (FIG. 1, *h*).

*Russula serissima* Peck resembles *R. squalida* much more than it does *R. xerampelina*, but the taste when young is peppery and the spores are larger varying from  $8.75 \times 10 \mu$  to  $9.37 \times 13 \mu$  (FIG. 1, *i*).

*Russula fucosa* Burl. is plainly distinct in its much paler spores and small size, the slow and less deep discoloration of the flesh and lamellae. In ten collections made on Newfane Hill, Vt., during the past two summers I have found that in the button stage the taste is slowly but plainly peppery. The spores (FIG. 1, *k*) are flesh color 67 t 3-4 while those of *Russula xerampelina* Fries are maize tone 3-4. The average size of the adult spores is from  $8.75 \times 8.75 \mu$  to  $8 \times 10 \mu$ . They are coarsely echinulate

<sup>2</sup> The Agaricaceae of Michigan, p. 146.

with the protuberances varying in size and sometimes crowded, and rarely with a few fine lines. Unless it should be found that all young of *Russula xerampelina* Fries are acrid, certainly *Russula serissima* Peck and *Russula fucosa* Burl. should be considered distinct species. And the mild form with the constantly white stipe and less compact texture can easily be distinguished as *Russula squalida* Peck.

Regarding *Russula cinerascens* Beards., Mr. Beardslee wrote to me previous to the publication of the species, "I have been watching this species all summer." Had there been an acrid taste he would have discovered it. On the other hand, Dr. Burke readily found that his species was acrid in taste. The spores of *Russula cinerascens* appear nearly smooth under oil immersion until the iodine stain is used when the protuberances barely show on the circumference and are very minute over the surface, some being connected by very fine lines (FIG. 1, *l*). Those of *Russula Burkei* are plainly tuberculate and more reticulate (FIG. 1, *m*). On the basis of the acidity and the presence of an odor which Burke considered similar to that of *R. foetens* and the difference in spore markings regardless of any other differences this species would seem to be distinct from *Russula cinerascens*. Both species were described from southern states. Dr. Singer reports that he found *Russula Burkei* in New Hampshire. I have not seen these specimens.

Carleton Rea in his British Basidiomycetes describes the spores of *Russula luteotacta* Rea as white. He considered that Bresadola's identification of specimens as *Russula sardonina* Fries was incorrect and that they belonged with *R. luteotacta* Rea. Bresadola had given the spore color as hyaline. Julius Schaeffer considers the spores as almost white, paler than B of Crawshay's colors. In the Revision der Russula-Sammlung Romels by Julius Schaeffer published in 1939, he reports on page 53 *Russula luteotacta* which Romell had finally called *Russula rosella* in his herbarium. Among the water color illustrations which he cites is number 2147 without exsiccati. In my herbarium I have various specimens which Romell sent me, among which is this number 2147. On this packet he wrote, "*Russula rosella* in Herb. Stockholm, 10 Aug. 1902, in Frondose Park, fig. 2147,

spores pure white, pileus pure roseus, all parts turn yellow when touched, taste acrid." Mr. H. C. Beardslee who collected with Lars Romell has told me that Romell would not attempt to identify a *Russula* unless he had a 24 hour spore print! Hence we may accept Romell's statement that the spores of this species are white, in verification of Rea's description of the spore color. The specimens plainly show the change of stipe and parts of the pileus and lamellae to yellow. The spores of *Russula mexicana* Burl. which Singer considered to be *Russula luteotacta* Rea are pale yellow. Had the species been *R. luteotacta* Rea, Dr. Murrill could scarcely have avoided noticing the change to yellow which would have occurred in all parts where touched, and the adult specimens in the herbarium should show the changes. These two species illustrate the importance of complete field notes regarding either change or lack of change in the color due to bruising or cuts, and a dense spore print with the color when fresh matched by some standard color chart. The most satisfactory color charts are Color Standards and Nomenclature by Robert Ridgeway, and the Repertoire de Couleurs published by the Société Française des Crysanthémistes.

Due to restrictions in automobile travel, I have been unable to collect again *Russula rubrotincta* which grows in spruce woods in Stratton, Vermont, and check once more the taste of young specimens in all parts. But until I can find that some parts at some stage of development are acrid, I cannot consider it synonymous with *Russula paludosa* (*Russula elatior* Lindb.). I have collected the latter and found no difficulty in detecting the acrid taste. Peck first gave *rubrotincta* as a variety of *Russula integra* (L.) Fries. I have not found *Russula rubrotincta* growing in sphagnum swamps, which seems to be the habitat of *Russula paludosa*.

In my treatment of the genus *Russula* in North American Flora the American Code of Nomenclature was followed by which the earliest name for a species was used in case it had not been preempted. Since Batch had used the name *Agaricus olivascens* for another species in 1783 it was considered that *Agaricus olivascens* Secr. 1833 would need to be replaced by another name; hence the new name *subolivascens* was substituted in the com-



bination *Russula subolivascens*, and *Russula olivascens* Secr. was reduced to synonymy. In following the International Code the name given by Secretan would be retained as Dr. Singer states. Throughout the treatment of the genus *Russula* in North American Flora the American rules were followed. Moving forward the date for the acceptance of the name of a species certainly reduces the labor of finding what name is to be taken as the original, although in some cases it deprives the original discoverer of the species of his due honor. But it does reduce the danger of including under a species forms which do not belong there, and eventually describing under the name species very different from what the author had under observation. All of this difficulty however can be obviated by the preservation of type exsiccati. From now on in order to render the description of a new species valid, type specimens together with a satisfactory spore print should be deposited in some central herbarium in the country from which the species is described. If specimens are thoroughly dried, they can be preserved *indefinitely* either in screw topped glass jars or tightly covered tin boxes made in standard sizes for filing. The only danger then will be from mold which can be obviated by keeping the atmosphere dry in the herbarium room. Each specimen must be labeled so that it cannot be mixed with others. As far as material will permit authentic cotype or extype exsiccati should be deposited in the herbarium, in other leading Botanical Gardens or Colleges where mycological work is being done. Especially should this be done in the United States so that we may avoid the confusion of species which exists in Europe, and the mention of a species "in the sense of" this author or that one. Except in case of a species described in error as new, which would then become a synonym, a determination wrongly made should be dismissed as false and the species placed in its proper classification if data allow it to be correctly identified.

The descriptions of *Russula magnifica* Peck and *Russula polyphylla* Peck resemble each other, but since the latter had been described only five years previously, he undoubtedly considered it when describing *R. magnifica*. The most pronounced difference in gross structure is the very close arrangement of the lamellae in *R. polyphylla*. The spores of *R. magnifica* are more broadly

elliptical and appear nearly smooth under the 1/6 magnification. With the iodine stain and oil immersion they are seen to have small dot-like protuberances some of which seem to be arranged very close together in a row and occasionally they seem to be connected by almost invisible lines (FIG. 1, *n*). The spores of *R. polyphylla* are unsymmetrical, and a little longer in proportion to width, and have larger and fewer protuberances connected by lines rendering them reticulate (FIG. 1, *o*). With these two species we must also consider the difference in the type locality. While *R. magnifica* was found in sandy woods under *Kalmia* at Port Jefferson, N. Y., near Long Island Sound, the other was found ten degrees of latitude farther south, and inland. It is possible that the range of the two species does not overlap.

Some time ago when I attempted to make a critical study of the spores of *Russula flaviceps* Peck, I found that the type specimens had evidently been lost or at least misplaced. In mounting or boxing specimens, which is usually done by an assistant, it is very easy to mix or misplace specimens unless they are so labeled as to make this impossible. Even a type may thus be lost. Having known Peck and his work as I did, I cannot think that it was possible that such a careful collector and thorough student of this genus should have taken specimens of *Russula flava* as the type of *Russula flaviceps*. This condition emphasizes the need of attaching to each specimen in a type collection a label which will remain. Even in the absence of the type Peck's description is clear enough for the identification of the species. I have in my herbarium a collection from Newfane Hill, Vt., on July 21, 1919, and painted by Miss Ann Hibbard, also number 28—1920, the specimens of which agree perfectly with his description. The spores are ochroleucous in a dense print, plainly echinulate under the 1/6 power, subglobose to broadly elliptical,  $6.87 \mu \times 7.5-8.1 \mu$ , with tubercle-like protuberances and very fine lines connecting some. Especially after the iodine has been washed out these and the protuberances remain in blue (FIG. 1, *p*). The taste in flesh and lamellae is mild, soon slightly peppery. In older stages the taste may be entirely mild. It must not be confused with *Russula aurantialutea* Kauff. which has ochre lamellae and spores with a different ornamentation and in all

parts at all times a very acrid taste. Peck states that the species was rare and I have not found it common.

N. M. Glatfelter who sent the specimens to Peck from which he described *Russula eccentrica* later sent me one good specimen said to be from type material. In the dried condition it seems quite distinct in its rather distant reddish brown fairly broad lamellae with shorter ones intermixed. They are more distant than those of *Russula compacta* and the pileus does not seem as thick as does that of the latter. Unfortunately the taste was not recorded. Since the specimens were collected in a ravine the eccentric shape may prove to be incidental. The spores are nearly globose and under the  $1/6$  power appear nearly smooth. With iodine stain and higher power they are seen to have scattered dot-like protuberances. They are white and vary in size from  $5-7\ \mu \times 6-8\ \mu$ .

I cannot consider that *Russula variata* Banning & Peck is an acrid form of *Russula cyanoxantha* (Schaeff.) Fries as Dr. Singer suggests, first because I believe that acidity is a fundamental chemical characteristic which serves to distinguish a species from one which is mild, and secondly because the arrangement of the lamellae is different in the two species. In *Russula variata* the lamellae are narrow or in large specimens comparatively narrow, narrowed at each end, and dichotomously forked without short ones intermingled. Beginning at the stipe the lamellae will fork from two to three times before reaching the margin. In *Russula cyanoxantha* according to Fries, the lamellae are broad with shorter ones intermingled. In his painting he shows the forking next the stipe or part way to the margin. There seems to be no question that the taste is mild. Singer so describes it, and Julius Schaeffer calls it fully mild (Völig mild). The resemblance between the two species is chiefly in color variation of the pileus, and because of that similarity it is possible that some collections of *Russula cyanoxantha* may have been wrongly determined as *Russula variata* and have slipped into unverified collections in some herbaria. Our nearest species which might be mistaken for one or the other of these species is *Russula simulans* Burl., another acrid species but with unequal lamellae, forking once. It is doubtful whether *Russula variata* is ever

mild. This summer I have made several collections and in every case the taste was acrid even in one which was collected at the end of 36 hours of a series of showers. The spores are somewhat elongated in a lateral view, and vary from  $7.5\text{--}8.75\ \mu$  by  $10\text{--}11.25\ \mu$ . They have blunt protuberances of various sizes, some very small. They are mostly distinct but sometimes close enough together to appear almost connected. After the iodine stain has been washed out a few cobweb-like lines may appear connecting the bases of a few protuberances (FIG. 1, *q*). But the pattern seems to differ from that shown for spores of *R. cyanoxantha* shown by Julius Schaeffer in his Monograph t. 27, figure 3A. The ornamentation shown in figure 1, *q* is that of the average spore. Figure 1, *r* is a lateral view of a spore of *Russula simulans*. The protuberances are slightly larger than those on the spores of *Russula variata* and there are fewer dot-like ones. These spores illustrate the fact that in the same group there is likely to be a resemblance in pattern as has been stated. A spore drawing was also shown in Mycologia 13: f. 2, 131. 1921.

Since the spore of *Russula praeumbonata* in Mycologia 13: f. 5. 131. 1921 was not drawn from one stained with iodine, the ornamentation brought out by that method is shown in figure 1, *s*.

The microscopic study of cystidia, basidia and structure of the pileus is of great scientific value, and Dr. Singer is to be commended for his excellent work in his review of types. While helping in the group placement of species it may also sometimes assist in the determination of the species. But then some chemical or gross structural characteristic can undoubtedly be noted which will enable one to identify the species without this critical microscopic work.

The beauty of many species of *Russula* attracts some with an artistic ability to the study of the genus. Mrs. E. B. Blackford and Miss Ann Hibbard made many water color sketches which have been preserved in Boston. In addition Miss Hibbard spent several summers on Newfane Hill making water colored paintings of *Russulae* which she presented to me. In recognition of their work we have *Russula Blackfordae* Peck and *Russula Hibbardae* Burl. The water color drawings of fungi done by George E. Morris are preserved in the Peabody Museum of Salem, Mass.

The edible qualities of many species of *Russula* also have attracted others to the study of the genus, and they too have added to the knowledge of the genus. Hence it is desirable that in so far as possible the identification of the species should be made simple and exact with the aid of a hand lens only.

***Russula vesicatoria* sp. nov. (FIG. 2; 1-t)**

Pileus fleshy, firm, umbilicate with inrolled margin, finally spreading with depressed center, up to 11 cm. broad; surface white tinted maize yellow tone 1 to chamois tone 4 in the center, slightly viscid on the margin when wet, soon dry, cuticle adnate except on the edge, dull, often finely areolate over the central area; margin even, pruinose-downy under the lens, remaining inrolled on the extreme edge up to maturity; context white, unchanging, astringent to bitterish, slowly acrid but increasing and lasting and burning, odor strong but pleasant, somewhat like that of fresh *Lactaria camphorata*; lamellae fleshy white, unequal, some forking near the stipe or part way to the margin, narrow at the inner end, rounded at the outer end, very close; stipe white, very solid, tapering downward, somewhat pruinose downy at the apex, 2.2 cm.  $\times$  2.2 cm. at the apex to 1.5 cm. at the base; spores fleshy white 9 tone 4 to flesh color 67 tone 1 in thick mass, appearing echinulate under the 1/6 power, but under the oil immersion with stain showing fairly large protuberances with fine lines connecting some,  $6.8-7.5 \mu \times 8.37-8.75 \mu$ .

Pileo carnoso, firmo, umbilicato, margine incurvato, pruinoso-puberulo sub lente, postea expanso et centro depresso, albo, postea disco albidulo aut pallidoluteolo, margine cum udus est viscidulo, mox sicco, exstrio, centro cum exoletum est saepe areolato, 6-11 cm. lato; carne alba, astricta, amara, tum tarde acri, postremum et diu acerrima, subolida cum fracta est; lamellis albidulis, inaequalibus, furcatis, angustis, confertis; stipite albo, solido, ad apicem minute pruinoso-puberulo, constricto deorsum; sporis albidulis (9-t4 aut 67 t1), echinulatis, et lineis delicatis reticulatis,  $6.87-7.5 \mu \times 7.5-8.37 \mu$ .

TYPE LOCALITY: Near Lake Wildmere, Longwood, Florida.  
Type 1—Oct. 23—1941.

HABITAT: In black humus of lawn under scattered pines.

DISTRIBUTION: Longwood and near Apopka, Florida, also Davis Island, North Carolina.

This species belongs in the section *Compactae*, hence resembles the *Lactariae* but latex is lacking in all its stages and conditions. It has appeared regularly during the autumn when rains were favorable and Mrs. Nichols in whose lawn it grows says that it

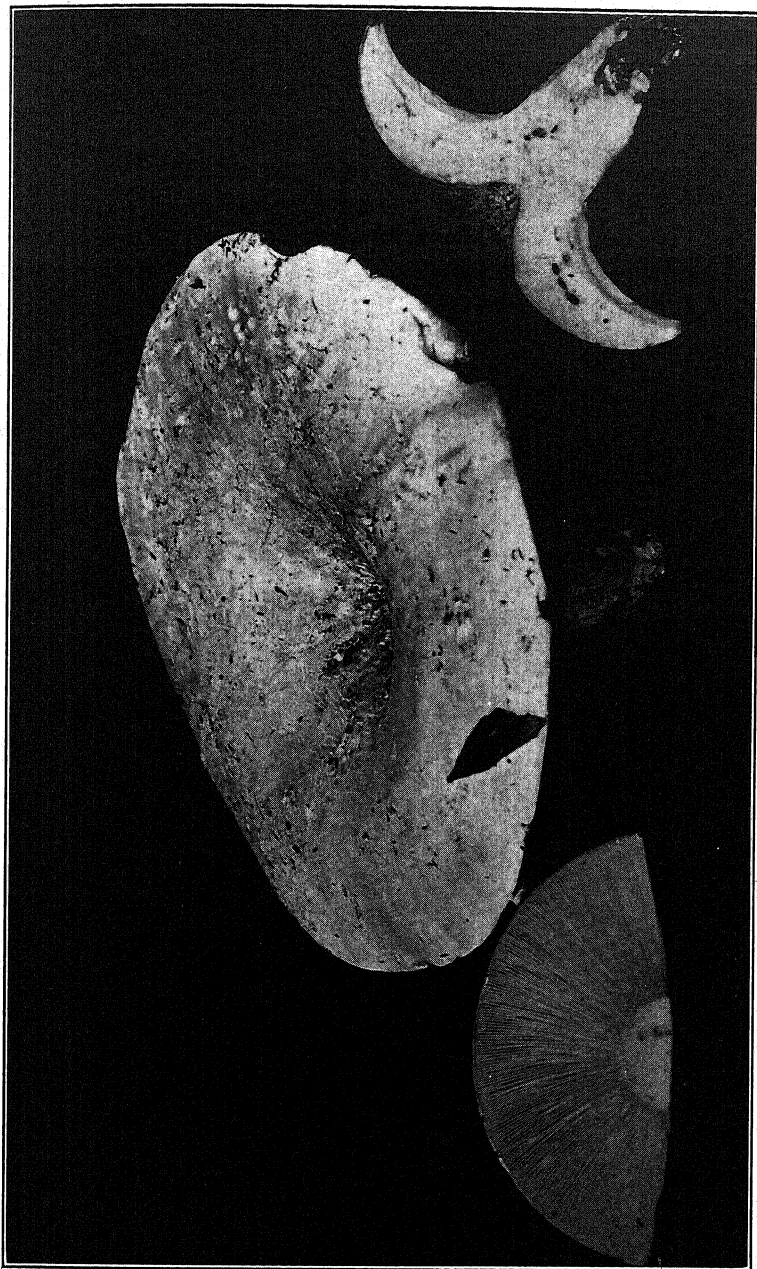


FIG. 2. *Russula vesicatoria* Burt.

also appears in summer. The taste is quite distinctive in that it first seems mild and somewhat bitterish, then acrid. The acidity remains on the tongue and lips for over twenty-four hours and finally results in blisters on lips and white-tipped tongue. Mr. H. C. Beardslee, who collected it on Davis Island, N. C., and also at Longwood, Fla., says, "I blistered my lips very thoroughly with it." The odor becomes apparent when the surface of the pileus is rubbed or scraped, or the mushroom is cut. It resembles somewhat the odor of fresh broken *Lactaria camphorata*, but the odor does not remain in drying. This odor and the very close narrow lamellae and firm structure of the pileus and stipe together with the nearly white color will serve to distinguish it when one once knows the mushroom, thus avoiding the necessity of tasting with its ill effects.

Type specimens are in my herbarium and co-type specimens in the herbarium of the New York Botanical Garden.

I wish to express my thanks to Prof. Arthur T. Walker of the University of Kansas for editing the Latin description of this species.

## NOTES AND BRIEF ARTICLES

### PLANT LIFE AND THE LAW OF MAN

The October number of *The Botanical Review* (9: 483-592) consists of "a history of legislation and litigation in the United States respecting eradication and quarantine of alternate hosts in the control of three heteroecious-fungus diseases—black stem-rust of wheat, white pine blister-rust and apple rust" by Dr. Edmund H. Fulling, Editor of *The Botanical Review*. The author has made an exhaustive study of the subject and presented the results in such a form that it is not only instructive, but exceedingly interesting reading. Separate numbers may be secured if desired.—FRED J. SEAVER.

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### A DICTIONARY OF THE FUNGI

The above named volume by G. C. Ainsworth and G. R. Bisby has just come to our desk. It comprises a list of the names of all genera of the fungi (not including bacteria and lichens) up to 1939; also the order to which the genus belongs, with the approximate number of species and their distribution. It is also a glossary of mycological terms and contains keys to families of the fungi. The generic names are used in agreement with the International Rules of Nomenclature so that unwarranted changes in the spelling or use of the name is not recognized.

The volume, consisting of 359 pages and 138 figures, is neatly bound. It is a most usable work, and a great time saver. This volume should be on the desk of every professional mycologist, as well as that of the amateur. It is to the mycologist what *Willie's Dictionary* is to the student of flowering plants and ferns.—FRED J. SEAVER.

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### A FEW CORRECTIONS

When one attempts to describe over six hundred new fungi without adequate herbarium and library facilities he is bound to



make mistakes. The collection of new material, also, and new publications will often change one's viewpoint. Then there are always friends to aid with valuable suggestions. Dr. Rolf Singer has been especially helpful in this way. He is responsible for at least eight of the corrections in the following list:

*Agaricus auricolor* Murr. = *Agaricus cylindriceps* Murr.

*Agaricus Weberianus* Murr. = *Agaricus Rhoadsii* Murr.

*Atylospora atomacea* Murr. = ***Naucoria atomacea*** Murr. comb. nov.

*Boletus viridiflavus* Coker & Beers = *Boletus flavimarginatus* Murr.

*Ceratomyces flavissimus* Murr. = *Ceratomyces aureissimus* Murr.

*Cortinarius praefelleus* Murr. = *Cortinarius prae brevipes* Murr.

*Cortinarius sublargus* Murr. = ***Cortinarius largiformis*** Murr. comb. nov.

*Cortinarius Westii* Murr. = *Cortinarius prae brevipes* Murr.

*Geopetalum albissimum* Murr. = ***Crepidotus albissimus*** Murr. comb. nov.

*Gymnopus alliaceus* Murr. = *Armillaria Boryana* (Berk. & Mont.) Murr.

*Gymnopus mammillatus* Murr. = *Gymnopus albistrictus* Murr.

*Gyroporus Rhoadsiae* Murr. = ***Tylophilus Rhoadsiae*** Murr. comb. nov.

*Hydnum virginianum* Murr. = *Sarcodon reticulatus* Banker

*Lactaria floridana* Beards. & Burl. = *Lactaria villosa* Clements

*Lactaria praeseriflua* Murr. = *Lactaria luteola* Peck

*Lactaria torminosa* Auct. Am. = *Lactaria villosa* Clements

*Lentodium floridanum* Murr. = ***Armillaria squamosidisca*** Murr. comb. nov.

*Lepiota trunciola* Murr. = *Lepiota subdryophila* Murr.

*Lepista prae villosa* Murr. = ***Inocybe prae villosa*** Murr. comb. nov.

*Marasmius squamosidiscus* Murr. = ***Armillaria squamosidisca*** Murr. comb. nov.

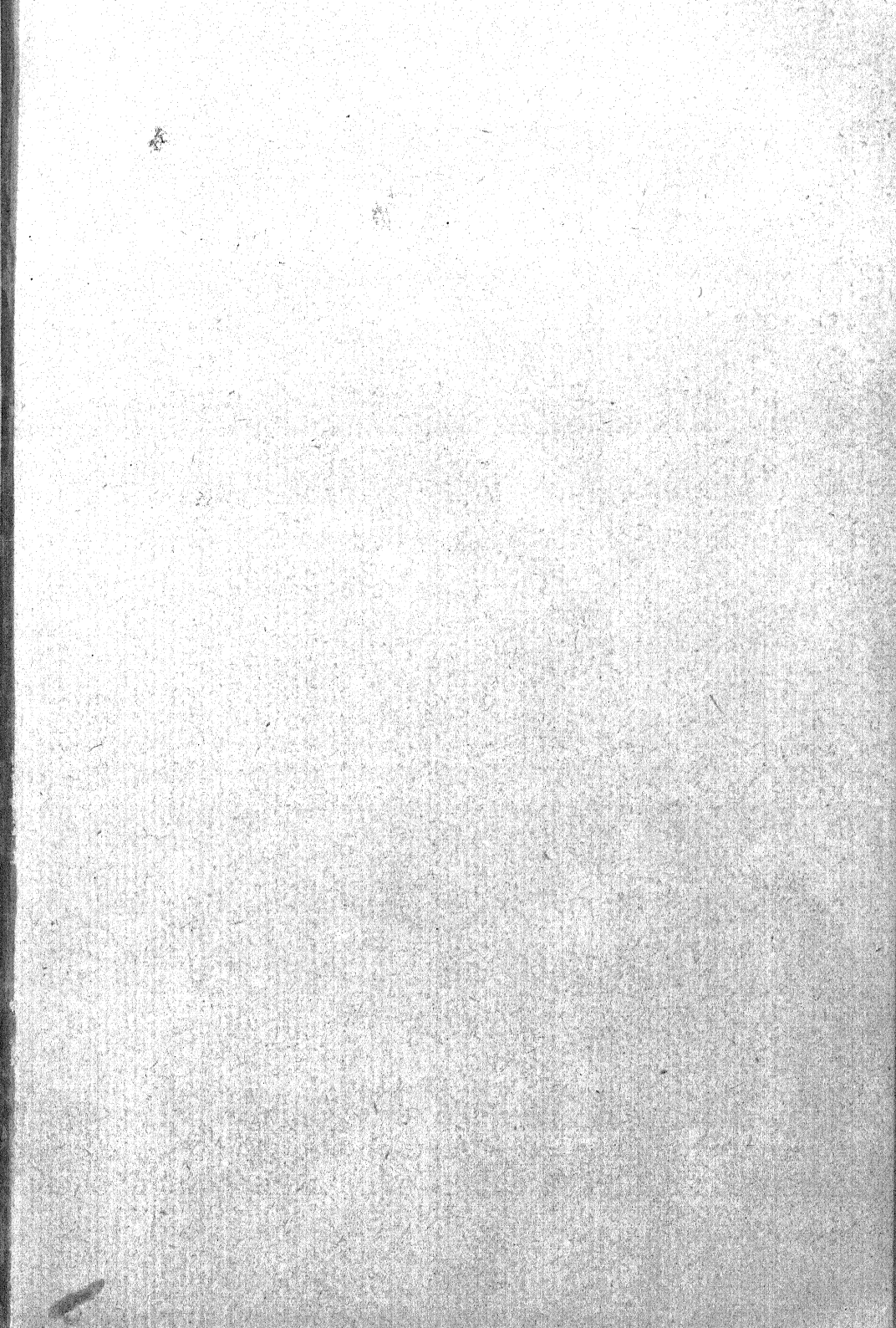
*Melanoleuca sublata* Murr. = ***Lactaria sublata*** Murr. comb. nov.

*Melanoleuca subrimosa* Murr. = *Melanoleuca entoloma* Murr.

*Russula lepidiformis* Murr. = *Russula lepida* Fr.

*Stropharia alachuana* Murr. = *Agaricus Rhoadsii* Murr.

W. A. MURRILL





WILLIAM CODMAN STURGIS

# MYCOLOGIA

OFFICIAL ORGAN OF THE MYCOLOGICAL SOCIETY OF AMERICA

VOL. XXXVI MARCH-APRIL, 1944

No. 2

## WILLIAM CODMAN STURGIS

ROBERT HAGELSTEIN

(WITH PORTRAIT)

William Codman Sturgis was born at Boston, Massachusetts, on November 15, 1862. He studied at Harvard, receiving degrees in 1884, 1887 and 1889. His first scientific work was as assistant in the Cryptogamic Laboratory of Harvard, followed as vegetable pathologist at the Connecticut Agricultural Experiment Station, lecturing meanwhile at the Yale School of Forestry. In 1904 he joined the staff of Colorado College, and later for nearly ten years was dean of the School of Forestry there. In 1917 he came to New York, and the remaining years of his life were connected with various activities of the Protestant Episcopal Church. He passed away on September 29, 1942.

Dr. Sturgis is perhaps best known for his studies on the Myxomycetes, although his work in plant pathology, forestry and mycology is not to be ignored. He became interested in the group while in Connecticut, and visiting England in one of the early years of the century, he was a guest for some time at the home of Mr. and Mrs. Arthur Lister. That visit resulted in lengthy correspondence with Mr. Lister until the latter's death, and continued with his talented daughter, Miss G. Lister, for many years afterward. From each he received many rare specimens, particularly of type material of new species proposed by them.

During his long residence in Colorado, Dr. Sturgis made extensive collections of the Myxomycetes of the State, among which [MYCOLOGIA for January-February (36: 1-122) was issued February 1, 1944.]

were several forms which he proposed as new species. The results of the study of these specimens, as well as other researches in the group, were published in different scientific journals. The entire collections of Dr. Sturgis, together with his notes, books, and correspondence, are now in the Herbarium of the New York Botanical Garden.

My personal acquaintance came about in New York in 1924 when I heard he had his office but a few blocks removed from mine. That acquaintance ripened into a friendship, and I recall with tender memories the many happy hours spent together in discussing problems connected with our mutual hobby. I met him last on a visit to his beautiful home at Annisquam, Massachusetts, during the month of May, 1938.

With the passing of each dear friend, and as we grow older, there is a void in our hearts which cannot be filled. As I sit at dusk, fond recollections come back to me of the long, long ago.

THE NEW YORK BOTANICAL GARDEN,  
BRONX, NEW YORK CITY

## FUNGI OF SOUTHERN CALIFORNIA—II<sup>1</sup>

ALEXANDER H. SMITH AND PAUL M. REA

As already pointed out by Rea,<sup>2</sup> the fungous flora of southern California has a number of interesting aspects. Several years of field work have already yielded valuable information on the distribution of fungi in the southwestern corner of the United States and, as is to be expected in a survey of any relatively unexplored region, a number of very odd and interesting agarics have been collected. Some of these are the subject of this report. Others are withheld for the present because they belong to groups in which the distinguishing characters are not sharp and more information is needed to justify extensive revisions. Since a comprehensive fungous flora of this region is a remote possibility, serial publication of the studies as they progress is desirable to make the results available to other workers, particularly those engaged in critical revisions of generic concepts.

This paper treats eight species, four of them new, distributed in *Amanitopsis*, *Armillaria*, *Cortinarius*, *Lepiota* and *Melanoleuca*. The genus *Melanoleuca* is used in the sense of Patoulliard, not Murrill. The most interesting of the new species is perhaps *Armillaria subcaligata*, which is characterized by ellipsoid, amyloid spores, bilateral gill trama, adnexed-seceding lamellae and the general appearance of *A. caligata*. Because of its gill trama, its relationships must be in the *A. imperialis* group of species, but the latter is characterized by differently shaped spores and long-decurrent lamellae. *Melanoleuca Lewisii* is a fine example of how deceiving external appearances can be. Most species of *Melanoleuca* are so similar in stature that the genus can usually be identified at sight, though the species can be distinguished only after careful study. The genus is similar to *Russula* in this respect. In *M. Lewisii*, however, we have a species which does

<sup>1</sup> Papers from the University of Michigan Herbarium and from the Herbarium of Paul and Marian Rea, Santa Barbara, California.

<sup>2</sup> Rea, Fungi of Southern California I. *Mycologia* 34: 563-574. 1942.



not resemble a *Melanoleuca* in appearance but must necessarily be placed there by virtue of the microscopic characters upon which the genus is based.

*AMANITOPSIS VELOSA* Peck.

Pileus 4-9.5 cm. broad, convex to nearly plane, viscid when wet but soon dry, pale buff to orange-buff, margin sulcate-striate (very rarely even), almost invariably with one large patch of the thick felt-like white volva covering the disc, usually glabrous elsewhere; flesh white, unchanging, thick next to the stipe, 4-10 mm., thinning rapidly to the margin, odor strong and pungent; lamellae close, usually pale creamy but often white, sometimes assuming a pronounced pink color when past maturity, broadest near the cap margin (5-8 mm.), subventricose, narrowed toward the stipe and decurrent on it by lines, edges fimbriate; stipe 8-15 cm. long, stout, 6-9.5 mm. or more thick at the apex, equal or slightly tapering upward, not bulbous, the base within the volva tapering to a point, pruinose above and roughened by decurrent lines where the lamellae were attached and then torn loose, without an annulus but sometimes with an obscure zone where the margin of the pileus was in contact with the stipe, glabrous below but with the cortex sometimes ruptured in irregular partial rings by the elongation of the stipe, white within, solid, with a central pithy core, becoming hollow; volva white, ample, membranous, closely sheathing the base for about 2 cm., dividing above into two limbs, the outer free, about 1 cm. long, with a more or less regular margin, the inner thicker, short, usually 3-4 mm., pressed against the stipe, in some specimens showing clearly that it is part of the cortex of the stipe ruptured by elongation of the latter.

Spores globose to ovate,  $8.4-11(12.6) \times 6-10.8 \mu$ , hyaline, apiculate, not amyloid, smooth; basidia 4-spored, occasionally 2-spored,  $60-80 \times 12-14 \mu$ ; pleurocystidia not differentiated; cheilocystidia more or less like sterile basidia (hardly differentiated); gill trama of somewhat divergent hyphae, not amyloid; pileus trama floccose beneath a thick gelatinous pellicle, not amyloid.

Solitary to gregarious, usually under or near oak trees, common, February to April in the region around Santa Barbara. The type locality is Pasadena, Calif. Wm. B. Gruber collected it in the vicinity of Roseburg, Ore., Apr. 14, 1942.

*Observations:* In early development, before expansion, the

fundamental tissue surrounds the stipe and extends in a very thin sheet between it and the lamellae, with which it is intimately united. It is the thinness of this sheet that prevents formation of an annulus. Expansion of the pileus tears the lamellae free and leaves their edges fimbriate. Most of the fundamental tissue then collapses on the stipe. The exposed surface of this tissue is striate above from the lamellae. Toward the base of the stipe it is thicker and soon becomes ruptured transversely as the stipe elongates leaving the lower part as the inner limb of the volva. Sometimes when the line of rupture is uneven its irregularities correspond on the rim of the inner volva and on the bottom of the cortex above. This development is similar to that of *A. vaginata* as described by Atkinson, and these species appear to be closely related. However, *A. velosa* is distinguished by its pungent odor, the heavy calyptra, color of the pileus, lamellae reaching the stipe, regular presence of the inner volva and the variation of the spores from globose to ovate. *A. vaginata* sometimes has a few volval remains on the pileus but seldom if ever a large, thick calyptra. It sometimes has an inner volva. *A. vaginata fulva*, as we know it, is more tawny. Its spores are described as globose and we have always found them so, whereas in *A. velosa* the spores, although often globose, are commonly as much as  $3\ \mu$  longer than broad. In a series of 82 spores from 11 collections the average size is  $10.5 \times 8\ \mu$ .

*A. velosa* also appears to be closely related to *Amanita calyptroderma*. Both are biovulate and calyptrate, have a striate margin, lamellae reaching the stipe at least at first, and non-amyloid spores. Although the latter species has a pileus about twice as large as the former and is much more robust in all its parts, its chief distinction is the presence of an annulus which is ample, though thin, and which readily collapses on the stipe. The formation of the annulus is due merely to slightly greater strength of the upper part of the fundamental tissue. Since the annulus is strictly apical, the striations from the lamellae are on its upper surface rather than on the stipe. Because of their pink gills, old carpophores of *A. velosa* may at times be mistaken for a species of *Volvaria* if one does not take the trouble to obtain a spore print.



*Armillaria subcaligata* sp. nov.

Pileus 5–11 cm. latus, convexus, demum late convexus vel planus, squamosus; squamae vinaceo-brunneae,  $5 \pm$  mm. latae, recurvae vel ad marginem pilei applanatae; lamellae latae, subventricosae, secedentes, subdistantes, albiae vel pallide luteotinctae; stipes 6–10.5 cm. longus, 2 cm. crassus, deorsum attenuatus, sursum glaber et albidus, deorsum peronatus, solidus; annulus  $1 \pm$  mm. crassus, infero luteo-brunneus, superne albidus; sporae  $9.6\text{--}12 \times 7.7\text{--}9.6 \mu$ , amyloideae.

Pileus 5–11 cm. broad, broadly convex, expanding to nearly plane but not becoming umbonate, surface dry and covered with large subpyramidal innate scales  $5 \pm$  mm. in width, scales pinkish brown with darker tips, toward the margin the scales more fibrillose and appressed, the flesh between the scales (ground color) whitish, the margin incurved and exceeding the lamellae by 3–4 mm. and the inner side striate from contact with the lamellae; flesh pure white, unchanging, compact but soft, 13 mm. thick next to the stipe, thinning gradually to 2 mm. at the margin, odor none; lamellae very broad (15–18 mm.), subventricose, rounded behind and definitely adnexed but seceding, leaving decurrent lines on the stipe, thin, white with a faintly yellowish and waxy tinge, subdistant, unequal, not forking, edges eroded; stipe 6–10.5 cm. long, about 2 cm. thick at the apex, narrowed downward, about 14 mm. at base, white and glabrous above the annulus, below the annulus sheathed by the thin yellowish-brown universal veil that forms subconcentric brown scales, solid, white within; annulus superior, the veil in the unbroken state  $1 \pm$  mm. thick and continuous with the flesh of the pileus, its upper or inner surface white and smooth, its lower or outer surface cottony-floccose and bearing thick brownish-capped scales like those of the pileus, soon collapsing on the stipe and becoming inconspicuous.

Spores  $9.6\text{--}12 \times 7.8\text{--}9.6 \mu$ , ellipsoid, amyloid, smooth; basidia  $50\text{--}60 \times 10\text{--}12 \mu$ , 4-spored; pleuro- and cheilocystidia not differentiated; gill trama with a central strand of more or less parallel hyphae with other hyphae diverging from it, not amyloid; pileus trama homogeneous, not amyloid, surface fibrils grouped into fascicles which form the scales.

Collected by Miss Heloise Coutelenc, Aug. 7, 1941, on a dry lawn near shrubbery in Santa Barbara, Calif.; in Herb. Paul and Marian Rea (994) and Univ. Mich. Herb.

*Observations:* The relationships of this species are puzzling. Although it is almost identical with *A. caligata* in stature, color

and veil characters, it differs sharply in having large, ellipsoid, amyloid spores and divergent gill trama. The ellipsoid spores, adnexed gills and veil characters make it difficult to place the species in either *Catathelasma* or *Biannularia*. Consequently we have described it in the Friesian genus *Armillaria* in order to place it on record. Most collectors along our west coast will doubtless confuse it with either *A. caligata* or *A. ponderosa* if the microscopic details are not checked.

***Cortinarius regalis* sp. nov.**

Pileus 8–12 cm. latus, subplanus, siccus, albofibrillosus vel subcalyptratus, glabrescens, subavellaneus vel avellaneo-subincarnatus; lamellae subdistantes, latae, pallidae dein umbrino-avellaneae; stipes 7–16 cm. longus, 18–35 mm. crassus, marginato-bulbosus, albidus vel pallidus, fibrillosus dein subsquamulosus; sporae  $7.2-8.4 \times 4.8-5.4 \mu$ .

Pileus 8–12 cm. broad, hemispheric with an inrolled margin at first, soon nearly plane, obtuse or broadly umbonate, the margin sometimes becoming wavy and at length somewhat raised, at first clothed with a thick, pure white fibrillose universal veil whose remnants often persist as a calyptra or in patches, cuticle beneath this covering "avellaneous"<sup>3</sup> with a faint tint of heliotrope, finally "vinaceous drab" (with a faint flesh tinge) and somewhat streaked with appressed fibrils, cuticle smooth and somewhat moist at first but no gelatinous pellicle present; flesh thick under the disc, thinner toward the margin, scissile and more or less watery punctate when fresh, drab in spots but gradually becoming a uniform vinaceous drab (paler than pileus); lamellae subdistant, inserted, broadest near the stipe, 8–11 mm., becoming ventricose as the pileus expands, very deeply emarginate-adnexed, pallid in the button stages (scarcely violaceous), becoming grayish brown to more or less chocolate brown when moist, paler and more rusty in dried specimens, not becoming purplish when bruised, edges even; stipe 7–10.5 (16) cm. long including the bulb, very thick, 18–35 mm. at apex, solid, its flesh watery punctate like that of the pileus and concolorous with it, tapering upward from the large strongly marginate-depressed or oblique turbinate bulb which is 4–6 cm. thick and 3.5–5 cm. deep to the tapered point, surface of stipe white to pallid, innately fibrillose, becoming coarsely lacerated in age, persistently decorated with abundant fibrils of the universal veil which are soon stained rusty from the spores, partial veil white and evanescent.

<sup>3</sup> All color names within quotation marks are taken from Ridgway, "Color Standards and Nomenclature," 1912.

Spores  $7.2-9.6 (10.8) \times 4.8-6 \mu$ , subellipsoid, nearly smooth, ferruginous in mass; basidia four-spored; pleuro- and cheilocystidia not differentiated; gill trama hyaline or nearly so in KOH, regular to somewhat interwoven, the hyphal cells not particularly inflated; pileus trama homogeneous beneath a thin nongelatinous pellicle of narrow ( $1-2 \mu$ ) hyaline hyphae with abundant clamp connections.

Densely gregarious to subcespitose in leaf mold under oaks, Santa Barbara, Calif., Jan. 28, 1940 (Rea 333, type), same locality again Feb. 7, 1940 (Rea 357). Part of both collections are in the Univ. Mich. Herbarium. It has also been collected under oaks in the Santa Ynez valley, Santa Barbara Co., Jan. 30, 1940 (Rea 334), and Jan. 20, 1944 (Rea 1309).

*Observations:* In spite of its watery flesh this fungus appears to belong in *Inoloma* rather than *Telamonia*, and is most closely related to the large form of *C. obliquus* Peck. Its manner of development is similar to that of *C. obliquus*, but it differs markedly in color. There are no true violet colors in *C. regalis* although a slight illusion of violet may be present at times in the cap or gills. The manner of development is similar to that found in *Bulbopodium*. The bulb may be depressed or merely oblique depending somewhat on the particular conditions at the time fruiting occurs. At times the flesh shows a tendency to turn yellow when cut but the change is not pronounced and the yellowish tints soon fade. *C. regalis* appears closely related to *C. argutus* but has distinctly smaller spores. Ricken gives the spores of the latter as  $13-15 \times 8-9 \mu$ . The colors and copious veil of the California species are further distinguishing characters.

#### LEPIOTA FLAVESCENS Morg.

Pileus (1.7) 2.5-4 cm. broad, at first cylindric-ovate and obtuse, at length expanded plane or with an obtuse or flattened umbo, plicate striate almost to the disc, pale greenish yellow (near "naphthalene yellow") over all except the disc, disc glabrous and brown at all stages and contrasting strongly with the rest of the surface, floccose to somewhat powdery over the ridges of the striae, the grooves merely fibrous and whiter; flesh yellowish, membranous; lamellae yellowish, close to subdistant, rather narrow, 2 mm., subventricose, free and remote, edges minutely fimbriate; stipe 3-6.5 (8) cm. long, 3-5 mm. thick at the base,

tapering gradually upward to 2 mm. or less at the apex when fully elongated, pale sulphur yellow and covered with fine yellow flocci like the pileus, hollow; annulus superior, pale yellow, delicate, often disappearing and occasionally becoming movable when the specimens have dried. Gregarious to cespitose, growing from an abundant white mycelium.

Spores  $4.8-6.6 (7.2) \times 3.5-5 (5.5) \mu$ , broadly ellipsoid to subglobose, not truncate, smooth, pale yellowish brown in iodine; basidia 4-spored,  $15-18 \times 7-8 \mu$ , clavate; paraphyses voluminous,  $14-18 \times 10-15 \mu$ , saccate and thin walled; pleurocystidia not seen; cheilocystidia abundant,  $28-43 \times 8-14 \mu$ , clavate, subcylindric or fusoid ventricose with obtuse apices, thin walled, hyaline; gill trama very loosely interwoven; pileus trama also loosely interwoven, corticated over the brownish disc with a compact palisade of enlarged (clavate to pear-shaped) thin walled cells, with scattered fascicles of inflated cells over the striate portion.

On humus in a greenhouse of Miss Kate Walker, Santa Barbara, California, July 26, 1941 (Rea 983), and from the same locality again in 1942: Aug. 14 (1115), Aug. 20 (1116) and Aug. 26 (1119). Specimens are also in the Univ. Mich. Herb. The description is based on collection 1115.

*Observations:* This species is very closely related to *L. lutea* but can readily be distinguished macroscopically by its dark brown glabrous disc and microscopically by its smaller spores which lack a truncate apex. It also appears to be very close to *L. denudata* Rab. sensu Kühner, but differs in not possessing sphaerocysts in the cuticle of the pileus. The disc is composed of a compact palisade of clavate to pear-shaped cells, and more or less the same type of cell covers the remainder of the surface at first but, owing to expansion, the layer becomes broken up and the cells are found in fascicles along the ridges of the striae at maturity. Judging by the descriptions, there is very little likelihood that *L. Allenae* Peck is different from the species described by Morgan. *L. flavescens* is also very close to *L. spectabilis* Clem. and may prove to be a variety of it. A fungus very similar to *L. spectabilis* was found growing with *L. flavescens* at Santa Barbara (Rea 1120). It has a paler pileus and yellow rather than brown disc. The spores and all other characters are as in *L. flavescens*.

## LEPIOTA GLATFELTERI Peck.

Pileus 2-9 cm. broad, globose when young, the margin resting on the bulb of the stipe, soon becoming truncate-subconic and at length broadly convex, the disc sometimes becoming slightly depressed, the margin deflexed and exceeding the lamellae, surface at first covered with a very thin, whitish film of the universal veil which soon becomes broken up leaving minute flecks over the central portion and quickly disappearing elsewhere, the cuticle dry, appressed fibrillose, subsquamulose toward the margin, "vinaceous rufous" to "vinaceous buff" (dull vinaceous to vinaceous gray), gradually becoming radiately rimose and exposing the white flesh toward the margin; flesh white, sometimes tinged vinaceous gray near the cuticle under the disc, cottony fibrillose, 3-7 mm. at the thickest point, very thin at the deflexed margin; lamellae white, sometimes faintly yellowish, close, unequal, not forking, subventricose, broadest (4-7 mm.) near the front, rounded behind, free but proximate, edges minutely fimbriate; stipe 2.5-5 cm. long, 4-8 mm. thick above, enlarged downward either gradually or abruptly to a distinct bulb 10-17 mm. thick which is clavate to globose, pure white over all, white within, surface glabrous to slightly fibrillose-floccose (as viewed under a lens), solid but soon stuffed with a white pith, base furnished with numerous white rhizomorphs; annulus inferior to median, membranous, white, about 2 mm. wide, sometimes adhering to the margin of the pileus as membranous patches but usually persistent on the stipe.

Spores white in mass,  $7.2-9.6 \times 4.2-4.8 \mu$ , chocolate brown in iodine, smooth, subovoid to ellipsoid; basidia clavate,  $16-18 \times 6 \mu$ , 4-spored; cheilocystidia abundant,  $26-43 \times 7.2-10-8 \mu$ , clavate to subventricose or broadly fusoid; gill trama homogeneous, of loosely interwoven hyphae; pileus trama loosely interwoven also, cuticle composed of elongated, slender, appressed, narrow ( $3-5 \mu$ ) hyphae with the pigment intracellular, no clamp connections seen.

Gregarious on soil in a lath-house of Miss Kate Walker, Santa Barbara, Calif., July 12 to Dec. 22, 1941 (Rea 968, 988, 996, 1001, 1013, 1017, 1070). Specimens have been deposited in Univ. Mich. Herb., N. Y. State Mus., and Missouri Bot. Gard. Specimens were also sent by Miss Walker to Miss Elizabeth E. Morse at Berkeley, Calif.

*Observations:* The type collection was made in Missouri and the species has not since been reported. The types at Albany

and part of the same collection at St. Louis, which were kindly lent us for examination, include only small specimens with slender stipes such as were collected early in the season at Santa Barbara. These are connected by intermediate stages with the much larger and the more robust plants that came up at the height of the season. Comparing the dried specimens, the cuticle of the type is "hair brown" instead of "light cinnamon-drab" as in the Santa Barbara collections, but this difference is slight and may easily have been caused by different methods of preparation. The spores of the type measure  $6-7.5 \times 4-4.5 \mu$  but were otherwise similar to those of Rea 988. The cheilocystidia are identical in both. The only possibly significant discrepancy is in the spore size. We have encountered as much variation in other species and we believe it should be disregarded here. The diagnostic characters are: the fibrillose nature of the cuticle and the intracellular pigment of its hyphae, the vinaceous color, bulbous and typically glabrous stipe and medium sized spores ( $6.5-9 \mu$ ).

We first encountered the species in 1936, but the most luxuriant fruiting occurred in August, 1941. More than a hundred carpophores in all stages of development were studied at that time. At first the globose pileus rest directly on the bulb of the stipe which is then broader than the cap. The early elongation of the stipe is above the partial veil, thus accommodating the growth in height of the pileus and causing the annulus to form just above the bulb. At this stage the shape of the pileus is distinctive. It is usually about 2 cm. high but 2.8 cm. broad just above the inflexed margin and slopes upward to the truncate or slightly depressed disc. As it matures it becomes broadly convex. Not all of the mature specimens become rimose and a few white flecks of the universal veil may frequently be found on the marginal area as well as on the disc. In many cases the later elongation of the stipe is not restricted to the part above the annulus, in which case the bulb becomes appreciably thinner and the annulus is eventually raised to a median position.

*L. Glatfelteri* should not be regarded as a hothouse species. The lath-house gave protection from direct sun and moderated the temperature. These conditions together with fairly abundant watering produced luxuriant crops from July to December.

During these months the chaparral from which the leaf mold came would not be expected to produce agarics because of the entire absence of rain. As yet we have not found the species fruiting in this area during the rainy season.

***Lepiota lutea* var. *aurantio-floccosa* var. nov.**

Pileus 3-5 cm. latus, siccus, aurantio-floccosus; lamellae pallide luteae; stipes clavatus, deorsum aurantio-floccosus; spores 8-11 (12)  $\times$  5-5-7  $\mu$ .

Pileus 3-5 cm. broad, at first ovate, at length plane, obtuse, striate for about 5 mm. in from the margin, minutely fibrillose-floccose, ground color "Martin's yellow" to "picric yellow," covered at first with orange to reddish brown floccose scales from the universal veil, the disc fibrillose-tomentose and reddish brown, near the margin the scales scattered and orange in color; flesh membranous, whitish or pale yellowish; lamellae close, white with a faint yellow tint, unequal, subventricose, 3-4 mm. broad, rounded behind, free and at length remote, edges minutely fimbriate; stipe 5-8 cm. long, 2-3 mm. thick above, gradually incrassate below into a clavate bulb about 6 mm. thick, pallid at the apex, concolorous with the pileus below, floccose (especially below the annulus), the bulb flecked with orange or reddish fragments of the universal veil, white or yellowish within, solid in the bulb, hollow above; annulus more or less fugacious, white with a yellow margin flecked with flocci of the orange universal veil.

Spores hyaline, ovoid, 8-11 (12)  $\times$  5.5-7  $\mu$ , apex truncate, smooth, dark chocolate in iodine; basidia 4-spored, subcapitate, 17-20  $\times$  7-9  $\mu$ ; paraphyses well differentiated, 18-22  $\times$  10-14  $\mu$ , saccate and thin-walled; pleurocystidia none; cheilocystidia 48-64  $\times$  9-12  $\mu$ , cylindric, subventricose or obtusely fusoid ventricose, thin-walled, abundant; gill trama loosely interwoven, homogeneous; pileus trama loosely filamentose, cuticle of pileus of more or less radially arranged fibrils of varying thickness, universal veil remnants of filamentose, branched, intricately interwoven hyphae 5-11  $\mu$  in diameter.

On humus in a greenhouse of Miss Kate Walker, Santa Barbara, Calif., Aug. 26, 1942. In Herb. Paul and Marian Rea (1117), also in the Univ. of Mich. Herb.

*Observations:* In the dried condition the universal veil remnants form a more or less dark avellaneous, floccose covering over the disc and are segregated into patches toward the margin. Thus

it appears their change in color in drying is distinctive. The plant is so similar to *L. lutea* in all characters except the color of the floccules that it is referred to that species as a variety. We have compared it with abundant collections of typical *L. lutea* which grew in the same greenhouse in 1941 and 1942.

We thought for a time that our plant might be *L. sulphurina* (Clem.) Sacc. The type of that species could not be found at Nebraska, but we were fortunate to receive from Dr. Clements authentic specimens collected by Edward Bessey on the ground at Lincoln, Neb., Aug. 19, 1895 (now 1265 in the Rea herbarium). We find these clearly distinguished from the various forms and varieties of *L. lutea* by narrower paraphyses (only 3–6  $\mu$  thick) which are not vesiculose at the time of spore discharge, and by the lack of a truncate apex on the spores (observed under oil). Kauffman thought that *L. sulphurina* was more likely an *Amanita* but it has a loosely floccose, homogeneous gill trama which proves conclusively that it is not in that genus.

#### **Melanoleuca Lewisii** sp. nov.

Pileus 4–8 cm. latus, convexus mox planus, glaber, viscidus, albidus dein pallide luteus; lamellae albidae, adnexae, latae, confertae; stipes 3–6 cm. longus, 1 cm. crassus, subbulbosus, fibrillosus, albidus; sporae 6–8.5–4–5  $\mu$ .

Pileus 4–8 cm. broad, convex to plane, obtuse, neither umbonate nor depressed, margin more or less undulating, not striate, not inflexed in drying, glabrous, slimy viscid when moist, pure white when young and fresh, in age becoming bright lemon yellow especially on the margin, when dried either whitish or pale yellowish; flesh white, 3–5 mm. thick in the disc, thin toward the margin (1–3 mm.), odor none, taste mild; lamellae pure white, broad,  $8 \pm$  mm., equal to subventricose, rounded behind, deeply emarginate adnexed but with a decurrent tooth, crowded, many lamellulae present, some anastomosing near the margin to give a pseudo-forking effect, edges undulating and white but becoming yellowish in drying; stipe usually short, 3–6 cm. long, stout,  $1 \pm$  cm. thick, sometimes compressed and  $8 \times 13$  mm., slightly flared at apex, base sometimes subbulbous, white, fibrillose, spongy and white within but soon hollowed by grubs.

Spores white in mass,  $6-8 (8.5) \times 4-5 \mu$ , ellipsoid, covered with strongly amyloid small warts; basidia clavate, 4-spored,  $30-36 \times 8-9 \mu$ ; pleuro- and cheilocystidia similar and scattered, fusoid-ventricose, the apex usually encrusted,  $46-64 \times 9-14 \mu$ ,



hyaline; gill trama subparallel to interwoven, the cells 6–22  $\mu$  in diameter and the length equally variable, not amyloid; pileus trama homogeneous beneath a thick, somewhat gelatinous pellicle of hyphae 4–7  $\mu$  in diameter, not amyloid, no clamp connections seen.

Gregarious to subcespitose, near Santa Barbara, California. First collected by Edward R. Lewis Feb. 18, 1939 (Rea 113), under chaparral at about 1000 ft. elevation (2 specimens only); later by Paul and Marian Rea under Monterey pine nearer sea level Mar. 2, 1940 (Rea 399), and Dec. 31, 1941 (Rea 1077). Parts of both the later collections are in the Univ. Mich. Herb. Collection 1077 is designated as the type because it includes more specimens and affords the best basis for the description. To Mr. Lewis we are indebted not only for discovery of this species but for many other interesting collections in 1939 and 1940.

*Observations:* Although the great majority of the species of *Melanoleuca* (sensu Patouillard) have a very similar stature and appearance, caused by the crowded narrow gills and strict, more or less longitudinally striate stipes, this alone cannot be relied upon to distinguish the genus. *M. Lewisii* resembles *Hebeloma crustuliniforme* in stature and, until a microscopic examination is made, one would not suspect it of belonging in *Melanoleuca*. The spores, cystidia, and lack of clamp connections, however, leave no doubt as to its proper genus. The stature, white color throughout when young, viscid pileus and yellowish tints in age distinguish it as a species. It does not appear to be very similar to any of the known species.

MELANOLEUCA REA! Singer, Cavanillesia 7: 6. 1935.

Pileus 2–6.5 cm. broad, campanulate to broadly convex or almost plane, sometimes with a small umbo, creamy with brown and sordid gray tints, dull, chalky, becoming shining upon drying, the slightly undulating margin inrolled when young; flesh thin except in the disc, creamy white, odor none, taste mild; lamellae broad, 5–8 mm., broadest in the midportion, sinuate-adnate, sometimes with a decurrent tooth, whitish, close, unequal; stipe 4–5 cm. long, up to 7 mm. thick, sometimes slightly eccentric, equal above the subbulbous base, pruinose toward the apex, fibrillose-striate below, with white basal tomentum, stipe

tissue continuous with that of pileus but of a different texture, stuffed and sordid white within.

Spores pale creamy in mass, hyaline under the microscope,  $8.4-9 \times 6-7.2 \mu$ , broadly ovoid, with very small, scattered, strongly amyloid warts over the surface; basidia 4-spored,  $28-32 \times 8-10 \mu$ ; pleurocystidia none; cheilocystidia inconspicuous and scattered to very rare, apices sometimes slightly encrusted,  $28-42 \times 5-6 \mu$ ; gill trama subparallel to interwoven, not amyloid; pileus trama homogeneous, the surface hyphae  $5-9 \mu$  in diameter, interwoven, clamp connections not found.

On a lawn, Montecito Country Club, Santa Barbara, California. Collected by Paul and Marian Rea Sept. 26, 1939 (Rea 217), and Nov. 16, 1939 (Rea 249). Part of both collections are in Univ. Mich. Herb.

*Observations:* The cream-colored spores, lack of a distinctive taste or odor, the very slender cheilocystidia, and the tendency of the stipe to be eccentric distinguish this species. *M. Reai* is the species described by C. Rea<sup>4</sup> under the name *Tricholoma subpulverulentum* (Pers.) Fries. Two discrepancies exist between the description of *T. subpulverulentum* and the California collections. The spores of the latter are distinctly larger and there is a slight tendency for the stipe to be eccentric. These characters may indicate a distinct western species, but for the present it appears best to interpret them as variants within *T. subpulverulentum*. Local races differing in spore size were found in *Leucopaxillus* for *L. giganteus* by Singer & Smith. We have observed that in many species of *Melanoleuca* there is a tendency for the stipe to be slightly eccentric, and consequently hesitate to place much emphasis on that character unless it is quite pronounced and constant. The important characters are the slightly yellowish spores and the somewhat pulverulent appearance of the pileus.

<sup>4</sup> Rea, Carlton, British Basidiomycetae. 1922.

# THREE HYPHOMYCETES THAT CAPTURE NEMATODES IN ADHESIVE NETWORKS

CHARLES DRECHSLER<sup>1</sup>

(WITH 5 FIGURES)

In several previous papers (4, 5, 6) descriptive treatment was given to 22 interrelated hyphomycetes found subsisting by the capture and destruction of eelworms infesting transparent agar plate cultures started from diseased rootlets or from other decaying vegetable materials. Similar treatment is devoted herein to 3 additional fungi of like biological habit and manifestly belonging to the same predaceous series. Capture of eelworms is accomplished, in all 3 fungi, by means of adhesive bail-like hyphal loops, which, as in allied forms, may occur singly, or may be compounded into networks of variable intricacy. Two of the fungi are referred to *Arthrobotrys*, one being presented as a new variety, while the other is identified with a long-established though somewhat unfamiliar species of that genus. The third fungus is described as a new species of *Dactylaria*. In relation to a subsidiary spore form apparently connected with the new species, preliminary discussion is devoted to a delicate *Trichothecium* found producing stalked adhesive knob-cells.

## A VARIETY OF ARTHROBOTRYS CLADODES WITH DISTINCTLY PEDICELLATE ELONGATED CONIDIA

A maize-meal-agar plate culture which after being permeated with *Pythium* mycelium had been further planted with small quantities of leaf mold collected near Beltsville, Md., early in October 1936, showed on subsequent examination numerous eelworms being captured and consumed by a small *Arthrobotrys*

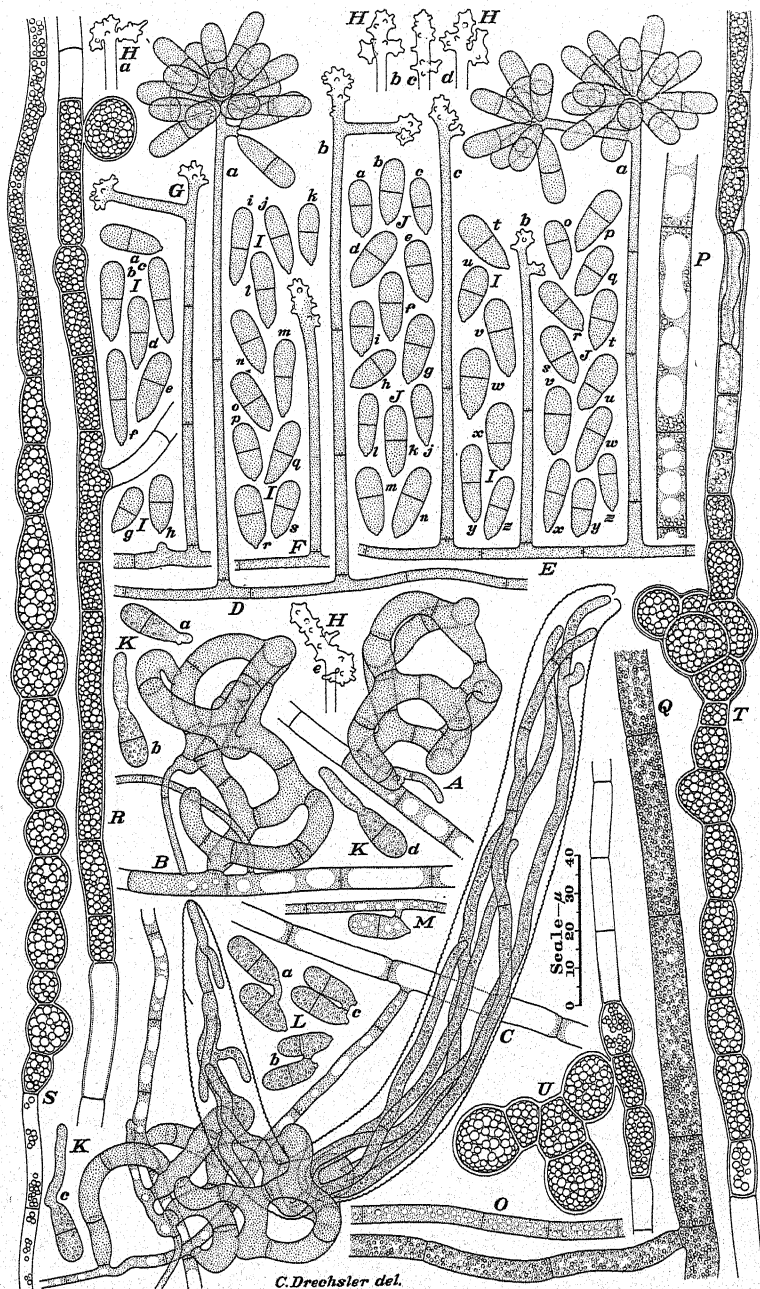
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having the general aspect of *A. superba* Corda or *A. cladodes* Drechsl. (4, p. 450-464). Since these two species, unlike most hyphomycetes of similar predaceous character, usually can not be distinguished well in nematode-infested agar cultures owing to the frequent failure of their conidiophores to develop beyond a simple monocephalous condition, the fungus was isolated by removing some of its conidia aseptically from their supporting hyphae to sterile agar in Petri dishes. When the plate cultures started in this way had grown for a few weeks, they showed little tendency toward the prolific uniaxial development of successive conidial clusters so characteristic of *A. superba*, but revealed instead a slower, more moderate multiplication of larger conidial heads through lateral branching of the conidiophores. Although with respect to sporulating habit the fungus thus agreed closely with the several strains of *A. cladodes* then familiar to me, it displayed readily noticeable differences in the more elongated shape and consistent pedicellation of its conidia, as well as in its production of more or less indurated resting bodies. Because of these differences the fungus was excluded from consideration at the time the specific description of *A. cladodes* was drawn up. It made its appearance more recently in some maize-meal-agar plate cultures started from decaying pansy roots collected in Mt. Rainier, Md., on May 21, 1943.

Grown in pure culture on Petri plates of maize-meal agar the fungus produces a commonplace mycelium composed of colorless branching filamentous hyphae, septate at moderate intervals, with the aperture of each cross-wall guarded on both sides by "Woronin bodies." When sizable slabs of agar medium newly permeated with young mycelium are removed to agar plate cultures abundantly infested with actively motile eelworms, hyphal bails and anastomosing networks are formed everywhere in the transferred slabs, and later are also produced at variable intervals along the rangy filamentous hyphae that grow out rather sparingly in all directions from the slabs. The networks often become 4 or 5 times more extensive than the examples illustrated in figure 1, *A, B*. They closely resemble the networks of *Arthrobotrys superba* and *A. oligospora* Fres. with respect to the width of their anastomosing hyphal elements, as well as

with respect to the size of their meshes. The resemblance extends also to manner of operation: relatively small, weak nematodes are often held merely through adhesion, while capture of larger and more energetic eelworms usually requires, besides, some degree of enmeshment (FIG. 1, C). Perforation of the animal's integument soon ensues through intrusion of a delicate process at some place where the network makes intimate contact with the prey. Often when enmeshment is rather loose, one of the hyphal elements nearest to the animal may give rise to a short stout branch that grows firmly against the integument and then narrowly penetrates it (FIG. 1, C). After penetration is accomplished the fungus produces within the integument a globose enlargement which soon puts forth assimilative hyphae to permeate the animal's body from head to tail. If the integument is penetrated in several places, a corresponding number of globose enlargements are usually intruded, all of them generally sharing in the invasion of the prey, though not necessarily in equal measure.

As invasion proceeds the animal's musculature and organs undergo globulose degeneration, the softer parts disintegrating more rapidly than the firmer tissues of the oesophagus and valve. During the period when the newly extended assimilative filaments are most active in appropriating contents of the prey, they likewise contain numerous globules, which, however, are generally smaller than those formed directly from the tissues of the nematode. Later, as the animal's substance nears exhaustion, the globules of the haustorial system diminish markedly. Since the assimilative filaments never grow out through the enveloping integument, nor give rise to erumpent branches, it is clear that the materials absorbed by the fungus are transferred backward into the hyphal loop or network from which the invasion began. As the last remnants of degenerating flesh disappear, the contents of the assimilative filaments begin to share in the backward movement; with the result that apart from the indurated spicules present in male specimens, the empty collapsing integument of the eelworm eventually surrounds only the equally empty membranous remains of the haustorial system.

FIG. 1. *Arthrobotrys cladodes* var. *macroides*.

The conidial apparatus produced in nematode-infested cultures is ordinarily too sparse to be seen with the naked eye. However, in pure culture on maize meal-agar plates, the fungus sporulates more freely; so that after about 5 days of growth a mycelium will usually reveal a delicate turf near its center. The conidiophores making up this downy turf closely resemble those formed in eelworm-infested cultures, since like the latter they commonly measure only 3 to 4  $\mu$  in width, and bear at the tip a bristling cluster of conidia (FIG. 1, *D, a*) together sometimes with a subsidiary cluster at the tip of a subapical spur (FIG. 1, *E, a*). While the clusters are mostly borne 110 to 150  $\mu$  above the surface of the substratum, relatively short conidiophores may bear their conidial heads at heights less than 100  $\mu$  (FIG. 1, *E, b*) or even less than 75  $\mu$  (FIG. 1, *F*). In its denuded condition the sporiferous tip of the main hypha (FIG. 1, *E, b, c; F*), as also the tip of the subapical spur (FIG. 1, *D, b; G*)—where a spur is present—reveals fairly pronounced, truncate denticulations. Often the sporiferous tip is found irregularly expanded or lobed in a manner to afford increased spatial capacity for attachment of conidia (FIG. 1, *H, a-e*).

During their earlier development in a Petri-plate culture conidiophores evidently arise only from filaments prostrate on the surface of the substratum, but after 2 or 3 weeks restricted areas often become covered with whitish aerial wefts, in which numerous conidiophores commonly arise from aerial filaments. These conidiophores, on declining toward the substratum, or even while still in an erect posture, frequently branch out near the base to give rise to secondary conidiophores; and the same process may be repeated several times. In instances where the older conidiophores remain more or less erect, those of secondary, tertiary, or quaternary origin may show rather pronounced curvature. Conidiophores resulting from the somewhat indeterminate development usual in aerial wefts often attain lengths varying between 200 and 300  $\mu$ , and basal widths between 4 and 6  $\mu$ .

As has been mentioned the conidia of the present fungus (FIG. 1, *I, a-z; J, a-z*) would seem appreciably longer and narrower than those produced in the cultures on which the description of *Arthrobotrys cladodes* was based. The relevant metric

data given in the diagnosis below were obtained by measuring 200 specimens taken at random in microscope mounts prepared from abundantly sporulating material. Expressed as the nearest integral number of microns, the values for length were distributable thus: 13  $\mu$ , 1; 14  $\mu$ , 2; 15  $\mu$ , 15; 16  $\mu$ , 29; 17  $\mu$ , 47; 18  $\mu$ , 48; 19  $\mu$ , 34; 20  $\mu$ , 14; 21  $\mu$ , 8; 23  $\mu$ , 1; 26  $\mu$ , 1; while the values for width were distributable as follows: 5  $\mu$ , 5; 6  $\mu$ , 102; 7  $\mu$ , 84; 8  $\mu$ , 9. Aside from dimensional differences the conidia diverge from those of *A. cladodes* in being drawn out at the proximal end into a distinct basal protrusion. Germination ensues very readily, much as in other members of the predaceous series. Often a germ tube is put forth from the proximal end (FIG. 1, K, *a-d*), but at other times, especially when anastomosis with another conidium (FIG. 1, L, *a-c*) or with a mycelial filament (FIG. 1, M) takes place, germination and vegetative union may be effected elsewhere than at the base.

On prolonged aging many of the submerged hyphae in maize-meal-agar cultures of the fungus gradually increase in width (FIG. 1, O), some becoming conspicuously vacuolate (FIG. 1, P), others becoming filled with numerous minute globules (FIG. 1, Q). Eventually most of the granular and globuliferous contents are collected in portions of filament consisting usually of 5 to 20 indurated segments. The segments may retain a cylindrical shape (FIG. 1, R), or, again, they may become more or less prominently inflated (FIG. 1, S). A branched arrangement of the segments is by no means uncommon (FIG. 1, R, T, U). Manifestly the groups of cells make up resting bodies of the same type as those produced abundantly in maize-meal-agar cultures of the predaceous species I have recently described as *Dactylella heterospora* (6, p. 339-349). Their resistance to desiccation would seem more than commensurate with the moderate induration suggested by their faintly yellowish coloration and the rather meager thickening of their walls. Like the chlamydospores of *Arthrobotrys oligospora* and of the two allied reticulate species I presented earlier under the binomials *A. conoides* (4, p. 473-477) and *Dactylaria thaumasia* (4, p. 518-523), they remained alive in maize-meal-agar cultures fully 4 years old, although during the



last 30 months of storage the medium was in a completely air-dry horny state (6, p. 346).

The fungus appears to merit recognition as a distinct variety; and is accordingly described under a varietal term meaning "of long form."

***Arthrobotrys cladodes* var. *macroides* var. nov.**

Mycelium effusum; hyphis hyalinis, septatis, primo plerumque 2–7  $\mu$  crassis, postea usque 11  $\mu$  crassis, laqueos tenaces arcuatos vel circulares in reticula saepe conjunctos evolvitibus; his laqueis vermiculos nematoideos tenentibus, deinde integumentum cuiusque animalis perforantibus, tuber debilitans vel mortiferum intrudentibus, hyphas intus evolvitibus quae carmen exhauriunt. Hyphae fertiles hyalinae, erectae, septatae, simplices vel aliquid ramosae, plerumque 75–300  $\mu$  altae, basi 2–6  $\mu$  crassae, subter apicem 1.5–2.5  $\mu$  crassae, apice dilatatae vel coralloideae, ibi ex denticulis obtusis 5–30 conidia in capitulum confertum ferentes. Conidia hyalina, elongato-ellipsoidea vel elongato-obovoidea, apice rotundata, basi obtuse pedicellata, 13–26  $\mu$  (saepe circa 17.6  $\mu$ ) longa, 5–8.2  $\mu$  (saepe circa 6.4  $\mu$ ) crassa, loculis duobus inter se nunc paene aequalibus, nunc inaequalibus, loculo superiore 5.5–13.4  $\mu$  (saepe circa 8.4  $\mu$ ) longo, loculo inferiore 6.4–12.4  $\mu$  (saepe circa 9.2  $\mu$ ) longo. Corpora perdurantia intra matricem orta, flavidula, protoplasmatis valde guttulosi repleta, modo simplicia modo paulum ramosa, vulgo 50–250  $\mu$  longa, in 5–20 cellulis saepius consistentia, cellulis vulgo 7–35  $\mu$  longis, 7–20  $\mu$  crassis.

Mycelium spreading; vegetative hyphae hyaline, septate, at first varying in width mostly from 2 to 7  $\mu$ , some later becoming wider and then occasionally attaining a diameter of 11  $\mu$ , in their young condition often, especially in the presence of nematodes, giving rise to sturdy hyphal bails and loops, which, though discrete in the beginning, are later frequently compounded into more or less extensive networks; the bails and networks capturing nematodes through adhesion and enmeshment, then perforating the integument of each captured animal and intruding one or more globose mortiferous excrescences from which are extended assimilative hyphae to appropriate the fleshy contents. Conidiophores hyaline, erect, septate, simple or somewhat branched, mostly 75 to 300  $\mu$  high, 2 to 6  $\mu$  wide at the base, 1.5 to 2.5  $\mu$  wide below the tip which frequently is somewhat widened or irregularly lobed and on which are borne 5 to 30 conidia in capitate arrangement. Conidia hyaline, elongate ellipsoidal or elongate obovoid, rounded at the distal end, provided with a distinct apiculum-like basal prominence at the proximal end, 13 to 26  $\mu$ , mostly 15 to 21  $\mu$  (average 17.6  $\mu$ ) long, 5 to 8.2  $\mu$  (average 6.4  $\mu$ ) wide, divided by a cross-wall at the middle, above the middle, or below the middle, the upper cell 5.5 to 13.4  $\mu$

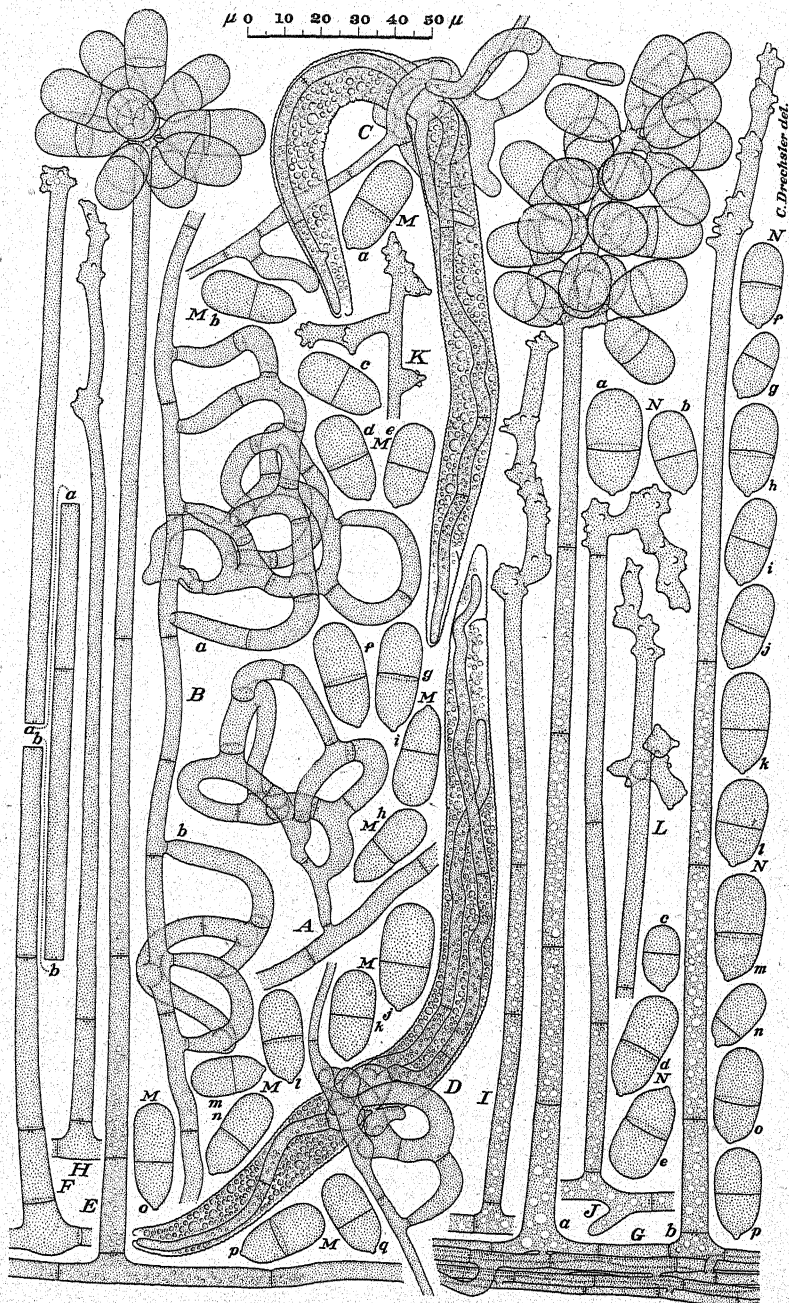
(average  $8.4\ \mu$ ) long, the lower cell  $6.4$  to  $12.4\ \mu$  (average  $9.2\ \mu$ ) long. Resting bodies formed tardily in the substratum, faintly yellowish, filled with pronouncedly globuliferous contents, mostly intercalary, simple or somewhat branched, commonly  $50$  to  $250\ \mu$  long, usually composed of  $5$  to  $20$  segments measuring individually  $7$  to  $35\ \mu$  in length and  $7$  to  $20\ \mu$  in width.

Capturing and consuming eelworms up to  $600\ \mu$  long referable to species of *Acrobeloides*, *Cephalobus*, *Plectus*, *Rhabditis* and other genera it occurs in decaying roots of *Viola tricolor* L. and in leaf mold in Maryland.

#### ARTHROBOTRYS ARTHROBOTRYOIDES (BERLESE) LINDAU

From time to time examination of agar plate cultures wherein nematodes were being destroyed by predaceous hyphomycetes has disclosed sparsely scattered conidiophores of robust stature, bearing aloft individually a terminal cluster of conidia which with respect to their largish dimensions appeared rather similar to the conidia of *Arthrobotrys oligospora*, but which with respect to their lesser tapering and nearly equal partitioning more nearly resembled those of *A. superba* or *A. cladodes*. Because of its ambiguous morphology the conidial apparatus in question was excluded from consideration in my treatment of the 3 species mentioned. More recently the fungus here concerned was isolated from leaf mold gathered in deciduous wood near Presque Isle, Me., on Oct. 1, 1941, as well as from leaf mold gathered in deciduous woods near Fairfax, Va., on Nov. 10, 1942.

In pure culture on maize meal agar the fungus, like most other hyphomycetes of similar biological adaptation, grows rather rapidly to form a dense mycelium devoid of any modification for capture of animals. When a sizable slab permeated with young hyphae is removed from a growing culture to an agar plate culture infested with nematodes, adhesive hyphal bails and networks (FIG. 2, A; B, a, b) soon come to light, first appearing promiscuously throughout the transferred slab, and later developing at intervals along the straightforward, rangy filaments extended sparsely in all directions into the adjacent substratum. As might be expected the retiare apparatus promptly begins to capture some of the eelworms whose presence evoked its formation,

FIG. 2. *Arthrobotrys arthrobotryoides*.

capture being effected through adhesion and enmeshment. Before long the integument of each hapless animal is narrowly perforated by a delicate bud put forth from an enveloping (FIG. 2, C) or adjacent hyphal element; or, often, especially in instances where envelopment is loose at the beginning, from one or more short branches that grow firmly against the prey (FIG. 2, D). After being disabled from rapid intrusion of one (FIG. 1, C) or more (FIG. 1, D) bulbous excrescences, the eelworm is invaded from head to tail through the longitudinal extension of assimilative hyphae. Progressive globulose degeneration of musculature and fleshy organs, absorption of the resulting products by the assimilative hyphae, transfer of appropriated or elaborated materials backward through these hyphae into the external parts of the fungus, and withdrawal of protoplasm from the assimilative filaments—all these processes ensue in the same sequence as in allied forms.

When the fungus thus obtains its nourishment from eelworms rather than from the mass of substratum infested by them—presumably the infested substratum ordinarily becomes unusable as a food supply because of foulness brought on by heavy bacterial contamination—it gives rise to a relatively sparse array of conidiophores. These conidiophores, as has been intimated, are of robust stature, usually attaining a height of 300 to 450  $\mu$  before they produce from 5 to 10 conidia in a single terminal cluster (FIG. 2, E, F). Often they measure 5.5 to 8  $\mu$ , or even as much as 9  $\mu$ , in basal diameter, while varying from 4 to 5  $\mu$  in width some distance below the apex. When fully developed they frequently contain 4 or 5 or 6 cross-walls. After the conidia have fallen off, the somewhat expanded tip is revealed as being beset with bluntly truncate sterigmatic protuberances (FIG. 2, F).

When the fungus grows in pure culture, so that the more abundant nourishment of the substratum itself can be utilized, vegetative development and spore production are much more luxuriant. Under moist conditions aerial filaments often cohere longitudinally, and thereupon, as in *Arthrobotrys oligospora*, where similar hyphal fasciation was noted by Matruchot (10), become united through multiple anastomoses to form coarse mycelial strands from which conidiophores are given off erectly (FIG. 2,

*G, a, b*) or in somewhat promiscuous radial arrangement. Although some conidiophores formed here are fully as stout as those formed on nematode-infested materials, others are slenderer (FIG. 2, *H*), not a few measuring only from 4 to 5  $\mu$  in diameter (FIG. 2, *I, J*). Many of the conidiophores here produce a cluster of conidia at a height of 200  $\mu$  (FIG. 2, *H*), or even at substantially lesser heights (FIG. 2, *I, J*). If evaporation is reduced to prevent early desiccation the conidiophores continue to elongate distally and to form additional conidia, though not on a scale as spectacular as in cultures of *A. oligospora* and *A. superba* that have benefited from similar treatment. Apart from its lesser prolongation the extended conidiiferous spike here is marked by less distinct separation into a series of spore clusters. For although localization of conidial attachments at nodes is at times readily recognizable (FIG. 2, *H*), no less often a rather haphazard arrangement of sterigmatic prominences along a crooked (FIG. 2, *I, J*) or irregularly branched rachis (FIG. 2, *K, L*) denotes botryose aggregation rather than seriate clustering.

Conidiophores of the fungus can be distinguished with moderate certainty from those of *Arthrobotrys oligospora* even when, as usually in nematode-infested cultures, they are bearing aloft only between 5 and 10 conidia in a simple head (FIG. 2, *E*); the capitate arrangement here being noticeably more open with respect to the distal portions of the spores. The looser distal spacing can not be considered a fortuitous feature, but must be held to result from the shape of the conidia making up the cluster, since these, as a rule, taper less markedly from apex toward base than conidia of *A. oligospora*. Because of this lesser tapering, and because, further, their single cross-walls are generally placed in more nearly median positions than in *A. oligospora*, the conidia of the present species, on the whole, show less pronounced inequality in size between the larger distal cell and the smaller proximal cell (FIG. 2, *M, a-q; N, a-p*). In some conidia the 2 cells appear of nearly equal volume, and occasionally, indeed, the lower cell is larger than the upper one (FIG. 2, *N, c, g*).

Spore morphology, as in allied species, is strongly affected by the environmental conditions that attend development. Owing to their relatively large dimensions, and to the relatively high

degree of uniformity in size, shape, and septation revealed by them, the conidia produced in nematode-infested cultures at a temperature of about 20° C. (FIG. 2, *M*, *a-q*) may perhaps be regarded as most distinctive of the fungus. When development takes place at 20° C. in pure culture on a suitable medium like maize-meal-agar (FIG. 2, *G*, *a*; *N*, *a-p*), almost equal uniformity of size, shape, and septation prevails, especially if the substratum and sporiferous layer remain free of troublesome deposits of water. Measurements of 100 conidia selected at random in equal numbers from nematode-infested and pure cultures, which in both instances had developed at 20° C., gave values for length, expressed as the nearest integral number of microns, with a distribution as follows: 17  $\mu$ , 1; 18  $\mu$ , 2; 19  $\mu$ , 2; 20  $\mu$ , 4; 21  $\mu$ , 8; 22  $\mu$ , 3; 23  $\mu$ , 13; 24  $\mu$ , 16; 25  $\mu$ , 16; 26  $\mu$ , 14; 27  $\mu$ , 9; 28  $\mu$ , 6; 29  $\mu$ , 4; 30  $\mu$ , 2; and values for greatest width distributable thus: 10  $\mu$ , 6; 11  $\mu$ , 19; 12  $\mu$ , 37; 13  $\mu$ , 25; 14  $\mu$ , 11; 15  $\mu$ , 1; 16  $\mu$ , 1. The measurements yielded averages of 24.4  $\mu$  and 12.1  $\mu$  for length and width, respectively; and averages of 13.2  $\mu$  and 11.2  $\mu$  for length of upper cell and length of lower cell, respectively. In 85 of the 100 conidia the upper cell was clearly longer than the lower one; in 8 the two cells were of about equal length; in the remaining 7 the basal cell (including the basal prominence) was longer than the upper cell, though, owing to its usually somewhat smaller diameter, not always of greater volume.

The conidia (FIG. 3, *A*, *a-z*; *B*, *a-j*) developed in pure culture on maize-meal-agar at 28 to 32° C., a usual daily range of indoor temperatures near Beltsville, Md., include a large proportion of short ovoid and ellipsoidal specimens. Very often the plump spores of such origin reveal no cross-wall, apparently remaining continuous in their definitive state (FIG. 3, *B*, *a-j*). In septate specimens the two cells appear frequently of nearly equal size, though, on the whole, the upper cell here, too, would seem slightly to exceed the lower one in volume (FIG. 3, *A*, *a-z*).

In the morphology of its conidial apparatus the fungus agrees rather well with the illustrated description wherein more than half a century ago a hyphomycete found occasionally on moist rotten mulberry (*Morus alba* L.) wood at Padua in Northern Italy was presented by Berlese (1, 2) as a new variety, *arthrobo-*



*tryoides*, of *Cephalothecium roseum* Corda. The conidial dimensions given by Berlese, 20 to 22  $\mu$  for length and 9 to 10  $\mu$  for width, though somewhat smaller than the dimensions I consider most characteristic of my cultures, are yet very frequent when my cultures are grown at summer temperatures. Berlese's characterization of the conidia produced by his fungus as elongate-ovoid, uniseptate, rounded distally, often obtusely apiculate at the base, and with the upper cell only slightly more distended than the lower, applies accurately to the conidia produced by mine. Taken collectively, his figures, moreover, show very much the same approximation to equality in size of the two conidial segments that comes to light in my material. If, perhaps, in general, these figures show slightly greater constriction at the septum than is commonly evident in my cultures, or, for that matter, than might be justified by the term "vix" in Berlese's diagnosis, it may be profitable to recognize that at the small magnification employed a really minute feature could not have been represented clearly without some exaggeration.

As the Italian fungus bore its conidia on denticulations constantly present on the expanded apex of the erect fertile hypha, and sometimes present likewise on an intercalary node below the apex, Berlese recognized its resemblance to *Arthrotrrys superba*. That he nevertheless assimilated it to *Cephalothecium roseum* may very probably be attributed to the persistent misunderstanding through which, as has been related earlier (4, p. 469-471), *Arthrotrrys* was long confused with *Trichothecium* and *Cephalothecium*; though this misunderstanding would hardly seem to account for his very puzzling interpretation of *Cephalothecium* as a more developed form (una forma più sviluppata) of *Arthrotrrys*. Four years later, Matruchot (10), after distinguishing anew the basipetal development of conidia in *C. roseum* from the truly capitate sporulation of *Arthrotrrys*, pronounced Berlese's fungus to be beyond doubt *A. oligospora*.

The transfer of Berlese's fungus to *Arthrotrrys* can be viewed with more satisfaction than its identification with *A. oligospora*. Since Matruchot's text gives no ground for supposing that he had received authentic material from Berlese, the identification may be presumed to have been made solely from Berlese's description

and figures, and these, as has been intimated, appear better applicable to a fungus specifically alien to the one described by Fresenius. Rather curiously, Matruchot may actually have dealt at first hand with the same organism as Berlese, for his

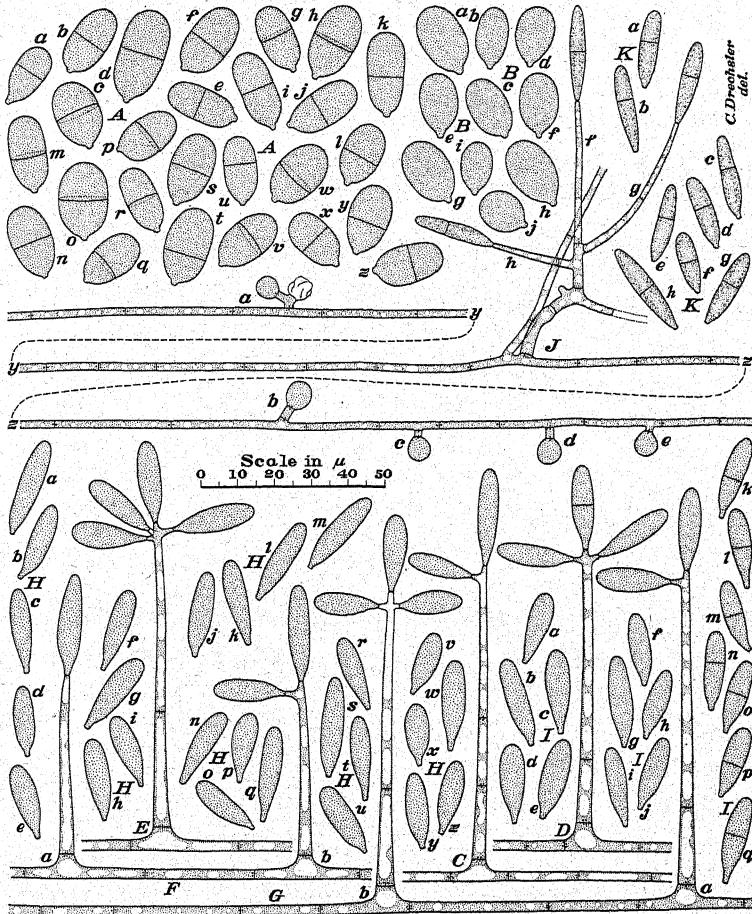


FIG. 3. A, B, *Arthrobotrys arthrobotryoides*; C-I, small hyphomycete resembling subsidiary sporulating stage of *Dactylaria psychrophila*; J-K, pre-daceous knob bearing fungus with a delicate *Trichothecium* stage.

illustrated account of the fungus he formally denominates as *A. superba* Corda var. *irregularis* Matr.—his other designations “la forme *irregularis* Matruchot” (10, p. 74) and “*Arthrobotrys irregularis*” (10, p. 109) are mentioned casually—presents fea-



tures more or less distinctive of the cultures I hold to be conspecific with Berlese's hyphomycete. Thus, Matruchot ascribes to the prolonged conidiophores of his variety a conspicuous irregularity with respect both to length of internodal portions and to the angles subtended at the nodes. To the nodes, moreover, he attributes a strong tendency toward lateral elongation whereby they sometimes acquire a somewhat branched or coral-oid-arbuscular form. The conidia he describes as having a length of  $25\ \mu$ , a maximum width of  $12\ \mu$  in the distal cell, and a greatest width of  $8\ \mu$  in the proximal cell. In several of the 9 conidia figured by him the inequality between the upper and the lower segment is not pronounced either with respect to width or with respect to size.

As the several peculiarities which Matruchot detected in material developing on rotten wood persisted during artificial cultivation on different substrata, he held them, not unjustifiably, to represent constant characteristics. In view, however, of what he considered extreme polymorphism in the fungi here concerned, he deemed it inadvisable to propose a separate species. Accordingly he subsumed his fungus under *Arthrobotrys superba* as a new variety, whereby it yet was given equal rank with *A. oligospora*, which likewise he recognized as a variety of Corda's species. It can only be presumed that apart from the variety *irregularis* all the *Arthrobotrys* material studied by Matruchot was referable to *A. oligospora*. In discussing briefly the "forme polyspore," which he observed on dry horse dung and which he held to be typical *A. superba*, he makes no mention of any distinctiveness attaching to the conidia. Most probably Matruchot, like other authors whose observations led them on the score of priority to apply Corda's binomial to *A. oligospora*, did not happen to encounter the much less frequent, less robust, but not less repeatedly capitate fungus that from the smaller dimensions and more nearly equal partitioning of its conidia corresponds much more closely to Corda's illustrated account, and therefore is better deserving of being identified with Corda's species.

It remains uncertain how much significance can properly be ascribed to the wide difference in the statements relating to length of conidiophorous filaments given respectively by Berlese and

Matruchot. In the diagnosis of *Cephalosporium roseum* var. *arthrobotryoides* a range of 150 to 200  $\mu$  is given for this dimension, whereas the erect branches of *Arthrobotrys superba* var. *irregularis* are stated to attain readily a length of several millimeters. Berlese's material may have developed on the natural substratum under conditions favoring cessation of growth in the individual conidiophore after development of a single conidial head—under conditions comparable, for example, to those operative in nematode-infested agar plate cultures, where as a rule *A. superba*, *A. oligospora*, and *A. conoides*, despite their strong tendency toward production of successive conidial clusters on a greatly prolonged uniaxial filament, are found in a monocephalous state almost as constantly as the purely monocephalous congeneric species I described under the binomial *A. musiformis* (4, p. 477–482). Yet Berlese's statement on length of fertile hyphae is not lacking in taxonomic import; for in my cultures of the fungus under discussion, the conidiophores, regardless of their ultimate length, often form their first conidial clusters at heights less than 200  $\mu$ , while, by way of contrast, conidiophores of *A. oligospora* only rarely produce the first conidial cluster less than 300  $\mu$  from the base.

The rather satisfactory agreement of my fungus with Berlese's description can be turned to account for nomenclatorial purposes all the more readily because Lindau (9, p. 371) in 1905 raised Berlese's variety to specific rank within the genus *Arthrobotrys* as *A. arthrobotryoides* (Berl.). The somewhat abridged German diagnosis given under the new binomial includes nearly all important details of the original account, though its failure to mention anything about the upper cell of the conidium being only slightly more distended than the lower cell appears unfortunate. However, in accordance with the type method of nomenclature, now firmly established, the omitted detail would seem to apply to the species no less than it applied to the variety; there being no question here of an intended factual correction as the transfer was made apparently without any first-hand examination of relevant material. Nor, apparently, has any usage intervened to modify the original characterization. Accordingly, in the absence of

serious adverse considerations, I am referring my fungus to *A. arthrobotryoides*.

Lindau expressed some uncertainty whether the species he renamed might not belong to *Arthrobotrys superba*; the latter being interpreted by him, as by Matruchot, to include *A. oligospora* as a somewhat depauperate variety. The fungus under discussion assuredly is separate from the congeneric form I hold referable to Corda's species; its separateness being manifest in parallel cultures despite the intimate interrelationship between all typical species of *Arthrobotrys*.

In old maize-meal-agar plate cultures the fungus occasionally gives rise to multicellular resting bodies through gradual distension and induration of uniaxial (FIG. 4, A) or branched (FIG. 4, B) portions of submerged hyphae. These resting bodies, like the similar structures of *Dactylella heterospora* and *Arthrobotrys cladodes* var. *macroides*, reveal pronouncedly globuliferous contents within walls that in many instances are thickened somewhat less markedly than the walls surrounding the more deeply colored chlamydospores produced in cultures of *A. oligospora*, *A. conoides*, *A. musiformis*, and *Dactylaria thaumasia*.

#### A RETIARY FUNGUS WITH UNUSUALLY LARGE PLURISEPTATE CONIDIA

A maize-meal-agar plate culture which after being permeated with *Pythium* mycelium had been further planted with a pinch of decaying material from old potato vines collected near Presque Isle, Me., on Oct. 2, 1941, showed, on examination 10 days later, development of a nematode-capturing fungus that presented some features in an unfamiliar combination. On its tall, sparsely scattered conidiophores were borne, for the most part singly, swollen ellipsoidal conidia, which, if predominantly triseptate, nevertheless very often contained 4 cross-walls (FIG. 4, C). The reproductive apparatus thus offered obvious parallelism with *Dactylella gephyropaga* Drechsl. (4, p. 508-513), except that the conidia here were of conspicuously greater length, often measuring more than 60  $\mu$  in this dimension. Further, the adhesive networks operative in capture of eelworms showed no scalariform development, but consisted throughout of arcuate or bail-like

elements, and hence greatly resembled the retiary apparatus displayed, among pluriseptate species, by *Dactylaria thaumasia* and *Dactylaria polycephala* Drechsl. (4, p. 527-531). As both of these species are sometimes difficult to identify with complete certainty in nematode-infested cultures, the fungus of ambiguous morphology was isolated by transferring aseptically some of the large conidia from their supporting hyphae to sterile maize-meal-agar plates.

The conidia germinated promptly, their germ tubes soon growing out into a compact branching mycelium, with numerous hyphal anastomoses and with all septa guarded by Woronin bodies. In the pure culture thus obtained the mycelium has never been found giving rise to predaceous organs. For a time no success was achieved in inducing development of predaceous apparatus by transferring sizable slabs of agar newly permeated with hyphae to Petri-plate cultures abundantly infested with active nematodes. The reason for this unexpected failure became clear when the temperature of the laboratory, ordinarily kept at about 25° C., went down to 17° C. for a period of several days. Under the cooler conditions hyphal bails and networks promptly came into being everywhere in the transferred slabs, and then were formed more gradually at intervals along the straightforward hyphae pushed out sparsely into the subjacent medium. Similarly luxuriant production of bails and networks took place whenever cultures containing the fungus in association with eelworms were kept at the lower temperature; many of the reticula becoming 5 or 6 times more extensive than the examples shown in figure 5, A, a-c. Contrary to expectations suggested by the robust dimensions of the conidia from which the pure culture was started, the networks have for the most part been rather more delicate than those of any other retiary species except *Dactylaria polycephala*. In their manner of operation they have shown no special distinctiveness. Eelworms measuring from 150 to 600  $\mu$  in length are held fast, partly by adhesion and partly by enmeshment. The integument of each eelworm is narrowly penetrated in one or more places; penetration being accomplished in each instance by a fine outgrowth that sometimes is extended from a thick stumpy branch thrust firmly against the animal

after its capture (FIG. 5, *B*), but at other times is extended from the inner side of an enveloping loop or from an adhesive hyphal element merely in close contact with the animal (FIG. 5, *C*). Wherever the integument has been perforated a globose enlargement is intruded, severing the animal internally and thus disabling it. Each globose enlargement soon gives off a few assimilative hyphae, which push their way lengthwise through musculature and organs, everywhere bringing about globulose degeneration. After the hyphae have completely taken up the globulose materials, their protoplasm is withdrawn backward into the external mycelium.

The relatively low temperatures between 15° and 20° C. not only permit a lively display of predaceous activity, but also are far more favorable than temperatures near 25° C. for development by the fungus of asexual reproductive apparatus. Under the cooler conditions the fungus promptly gives rise to numerous erect conidiophores, most of which soon come to support 2 (FIG. 5, *D*), 3 (FIG. 5, *E*) or 4 (FIG. 5, *F*) elongate ellipsoidal conidia. In large part the arrangement of plural conidia indicates successive development. Where, as is frequently the case, a spore is attached laterally at a slight geniculation a short distance below the apex bearing the terminal spore (FIG. 5, *D*, *a*, *b*; *E*, *b*, *c*), it may be presumed that the laterally sessile spore was formed originally at the tip of the supporting hypha, and was later pushed aside as the hypha resumed growth to produce another spore on its newly extended tip. Through repetition of this process 2 spores (FIG. 5, *F*, *b*, *c*) often come to be attached at successive geniculations below the apex bearing the terminal spore (FIG. 5, *F*, *d*); a strictly acropetal sequence of development being manifest in such instances. Frequently, in addition, a conidiophore may produce a conidium on the tip of a short spur-like branch (FIG. 5, *E*, *a*; *F*, *a*) arising usually from a position somewhat below that of the original axial tip; and, indeed, sometimes two lateral spurs are present, each bearing a conidium. Production of spores on such branches would seem more or less indeterminate with respect to time, except that it probably never precedes development of the first conidium on the main hyphal axis.

The conidia thus produced are the largest formed by any of the hyphomycetes so far known to subsist through capture of nematodes. Spores developed plentifully in maize meal-agar plate cultures at temperatures near 17° C. were used for the measurements underlying the data on conidial dimensions supplied in the diagnosis. The 100 specimens selected at random gave values for length, expressed as the nearest integral number of microns, with a distribution as follows: 46  $\mu$ , 1; 49  $\mu$ , 1; 53  $\mu$ , 1; 54  $\mu$ , 1; 55  $\mu$ , 2; 56  $\mu$ , 5; 57  $\mu$ , 2; 58  $\mu$ , 3; 59  $\mu$ , 2; 60  $\mu$ , 9; 61  $\mu$ , 13; 62  $\mu$ , 4; 63  $\mu$ , 12; 64  $\mu$ , 12; 65  $\mu$ , 12; 66  $\mu$ , 8; 67  $\mu$ , 2; 68  $\mu$ , 3; 69  $\mu$ , 4; 70  $\mu$ , 1; 71  $\mu$ , 2; and values for width distributed thus: 21  $\mu$ , 3; 22  $\mu$ , 7; 23  $\mu$ , 12; 24  $\mu$ , 20; 25  $\mu$ , 21; 26  $\mu$ , 19; 27  $\mu$ , 14; 28  $\mu$ , 2; 29  $\mu$ , 2. Of the 100 conidia 50 showed the triseptate partitioning usual in *Dactylella bembicodes* Drechsl. (4, p. 487-492), each consisting of a small basal cell, a small antepenultimate cell, a large penultimate cell, and a small apical cell (FIG. 5, *D*, *a*; *E*, *c*; *F*, *b*, *d*; *G-K*); the lengths of the 4 cells averaging, respectively, 8.2  $\mu$ , 8.5  $\mu$ , 37.6  $\mu$ , and 8.8  $\mu$ . Thirty-five of the 100 conidia showed the quadrisepate partitioning frequent in *D. ellipsospora* Grove (8; 4, p. 492-496), each consisting of a small basal cell, a small parabasal cell, a large median cell, a small penultimate cell, and a small apical cell (FIG. 5, *E*, *a*, *b*; *F*, *a*, *c*; *L-P*); the lengths of the 5 cells here averaging, respectively, 7.8  $\mu$ , 7.7  $\mu$ , 36.7  $\mu$ , 6.6  $\mu$ , and 4.2  $\mu$ . The remaining 15 conidia showed several types of partitioning: six were biseptate after the manner familiar in *D. heterospora*, each consisting of a small basal cell, a large median cell, and a small apical cell (FIG. 5, *Q*); one, though also biseptate, was divided into a small basal cell, a small penultimate cell, and a large distal cell (FIG. 5, *R*); three were composed individually of a small basal cell, a small parabasal cell, a small antepenultimate cell, a large penultimate cell, and a small apical cell (FIG. 5, *S*, *T*); four consisted individually of a small basal cell, a large antepenultimate cell, a small penultimate cell, and a small apical cell (FIG. 5, *U*); a single specimen with 5 cross-walls had its two large median cells intercalated between two smaller proximal cells and two smaller distal cells (FIG. 5, *V*).

Sporulation is less prompt and less abundant when the fungus is grown in maize meal-agar plate cultures at the relatively high

temperatures—mostly between 28° and 32° C.—prevailing indoors near Beltsville, Md., during the summer. Further, the conidia then produced are, in general, of smaller dimensions. This difference in size, appreciable even in the specimens that with regard to shape and septation (FIG. 4, *D*, *a-d*; *f-i*) show little divergence from those formed under cooler conditions, is especially marked in the frequently very numerous examples that clearly betray thwarted development in obovoid shape and meager partitioning by 1 or 2 proximal cross-walls (FIG. 4, *D*, *e*, *j-l*). A large proportion of the conidia germinate while still attached to their supporting hyphae by extending a germ tube from the distal end (FIG. 4, *E*). Where germination occurs after the spore has fallen off, the germ tube is more usually sent up from a position closer to the basal end (FIG. 4, *F*).

As the fungus never shows scalariform development but always forms its predaceous networks by adding one bail-like loop after another, it must be held to differ decisively from *Dactylella gephyropaga* in its vegetative stage. The composition and texture of its predaceous networks offer strong similarities with *Dactylaria polycephala*, which, however, is very adequately distinguished by conidial apparatus wherein pluriseptate conidia are frequently arranged in a succession of distinctly capitate clusters. As the 3 or 4 conidia commonly produced by conidiophores of the present fungus at suitably low temperatures are attached in positions often 5 to 25  $\mu$  apart, they offer a more or less capitate appearance mainly by virtue of their large dimensions. The difficulty of recognizing such loose arrangement as capitate clustering for diagnostic purposes is aggravated through the circumstance that with meager nourishment the conidiophores often bear only a single conidium or, perchance, two conidia, and then reveal a sporulating habit much like that of *D. gephyropaga* or of *Dactylella bembicodes*. Nevertheless, since its more luxuriant sporulation is apparently more expressive of good development than is its meager sporulation, the fungus would seem somewhat better referable to the capitate genus *Dactylaria* than to *Dactylella*. Assignment to the capitate genus, moreover, conveniently brings the fungus into the same fold with *Dactylaria thaumasia*, to which, from resemblances in character of preda-



ceous networks as well as from similarities in shape and arrangement of conidia, it seems most closely related. When grown in parallel cultures with *D. thaumasia* its separateness from that species is sufficiently evidenced in the larger dimensions of its conidia, in the production of these conidia in lesser numbers on the individual conidiophores, and in complete absence of chlamydospores.

Among the various hyphomycetes which have been made known without reference to any predaceous relationship, yet which from similarities of their conidial apparatus may be presumed to subsist by capture of nematodes, are two species with large swollen conidia that in respect to dimensions approach, even if they do not equal, the aerial spores produced in pure cultures of the present fungus under congenially cool conditions. One of these species, *Monacrosporium elegans* Oudemans (11), found on rabbit dung in The Netherlands, was set forth as giving rise to solitary, triseptate, mostly pyriform conidia, 50 to 60  $\mu$  long and 16 to 21  $\mu$  wide, on conidiophores about 250  $\mu$  high, 4 to 6  $\mu$  wide at the base and 2 to 3  $\mu$  wide at the tip. As the solitary condition of the conidium was affirmed not only in Oudemans' diagnosis of the species (Hyphae conidiophorae . . . singulae conidium solitarium gerentes . . .) but also in his definition of the genus *Monacrosporium* he erected at the time (Hyphae conidiophorae . . . apice unicum tantum conidium . . . gerentes) it may be inferred that in his material the tendency toward production of plural conidia, if present at all, was much feebler than in my cultures. The second of the two large-spored species here in question was found on a partly decayed male inflorescence of the oil palm, *Elaeis guineensis* Jacq., in Sumatra. It was presented by Boedijn as a new member of Oudemans' genus under the binomial *M. megasporum*, though its erect, unbranched, septate conidiophores, 300 to 500  $\mu$  long and 5.5 to 7.5  $\mu$  wide, were described as having at the tip several warty protuberances, each functional in serving as support of a separate conidium. Boedijn's figure shows several of the sterigmatic warts closely aggregated on the somewhat expanded apex of each conidiophore—an arrangement certainly much closer than that prevailing in my fungus. The conidia of *M. megasporum*, described in part



as being elliptical, as containing usually 3 septa, and as measuring 35 to 57.5  $\mu$  in length by 15.5 to 27.5  $\mu$  in width, would seem from the several examples illustrated, to taper less markedly toward base and apex than the conidia produced in my cultures, besides differing in being drawn out abruptly at the proximal end into a minute hilar protrusion.

Aside from comparison of reproductive structures, determination of predaceous hyphomycetes, and especially of hyphomycetes subsisting by capture of eelworms, necessarily entails consideration of agreement or disagreement with respect to predaceous apparatus. Unfortunately the literature pertaining to the group of fungi here concerned was written, for the most part, without any suspicion of predaceous relationships, so that treatment of the vegetative stage usually affords scope for comparison only with respect to the commonplace features of undifferentiated mycelium. In some instances, it is true, a fungus found capturing and consuming nematodes may be satisfactorily assigned to an established species even where no information is given as to the existence or character of predaceous organs in the material on which the species was based. Thus, since the several typical representatives of the genus *Arthrobotrys* which have been appropriately studied in living cultures—*A. dactyloides* Drechsl. (4, p. 482–487) must be held aberrant because of its production, now and then, of swollen bisepitate conidia—have all been found capturing nematodes by means of adhesive networks composed of bail-like hyphal loops,<sup>2</sup> there is good reason to presume that similar biological adaptation and similar predaceous apparatus belonged likewise to the similar fungi described as species by

<sup>2</sup> Very recently, however, an undeniable exception to the general rule has come to light in a predaceous hyphomycete specially adapted to capture minute Sminthurid springtails; the insects being held through adhesion to ovoid glandular cells borne aloft individually on short unicellular erect columnar stalks arising from different segments of a prostrate anastomosing hyphal network. Although the concomitant conidia, mostly about 22  $\mu$  long and 5  $\mu$  wide, are borne on longish sterigmatic spurs and thus appear in looser capitate arrangement than is prevalent in the better known congeneric nematode-capturing species, their consistently uniseptate condition, together with their production in well defined clusters that are formed terminally one after another on a slender conidiophore given to repeated uniaxial elongation, makes the fungus unreservedly eligible for inclusion in *Arthrobotrys*.

earlier observers. Consequently the determination of two retiary nematode-capturing fungi as *A. superba* and *A. arthrobotryoides* need arouse no serious misgiving with regard to correspondence in the vegetative stage, however silent the relevant descriptions by Corda and Berlese may be in respect to predaceous features. Lack of positive knowledge on adaptations for holding prey is, however, very serious where, as in the case of the fungus from Maine, comparison must be made with descriptions of broad-spored species of *Dactylella* (including *Monacrosporium*) and *Dactylaria*. For among such species are utilized all types of specialized apparatus known to be operative in capture of nematodes—constricting rings, adhesive networks compounded of bail-like hyphal loops, scalariform adhesive networks, adhesive knob-like cells on sturdy stalks, and smaller adhesive cells on frail stalks together with non-constricting rings; so that here the conidiophores and conidia, in themselves, give little indication as to which type of predaceous apparatus might be associated with them. Hence, even if the fungus from Maine agreed well in its reproductive structures to the description of *M. elegans* or of *M. megasporum*, a strong possibility of outright disagreement in the vegetative stage would nevertheless remain.

The fungus, therefore, is described as a new species. A specific term compounded of words meaning, respectively, "cold" and "to love" may serve conveniently to direct attention to its thermal preference.

### *Dactylaria psychrophila* sp. nov.

Mycelium effusum; hyphis sterilibus hyalinis, septatis, plerumque 2–6  $\mu$  crassis, laqueos tenaces arcuatos vel circulares in reticula saepe conjunctos proferentibus; his laqueis reticulisque vermiculos nematodeos illaqueantibus, deinde tum integumentum animalis captivi perforantibus, tuber debilitans vel mortiferum intrudentibus, hyphas intus evolvantibus quae carnem exhauriunt. Hyphae fertiles incoloratae, septatae, erectae, plerumque 150–500  $\mu$  altae, basi 5–9  $\mu$  crassae, apice 2.5–4.5  $\mu$  crassae, modo simplices modo subter apicem uno ramulo usque 35  $\mu$  longo (quandoque duobus ramulis ejusmodi) instructae, primum 1 vel 2 conidia gignentis, mox semel vel bis recrescentes et 1 vel 2 alia conidia deinceps gerentes, itaque postea 3 vel 4 conidia in capitulum laxum saepe ferentes. Conidia hyalina, ellipsoidea vel fusosideo-ellipsoidea, sursum rotundata, deorsum truncata, 1–5 septata vulgo triseptata vel quadrisepata, plerumque 46–71  $\mu$  (saepius circa 62.3  $\mu$ ) longa, 21–29  $\mu$  (saepius circa 24.7  $\mu$ ) crassa.

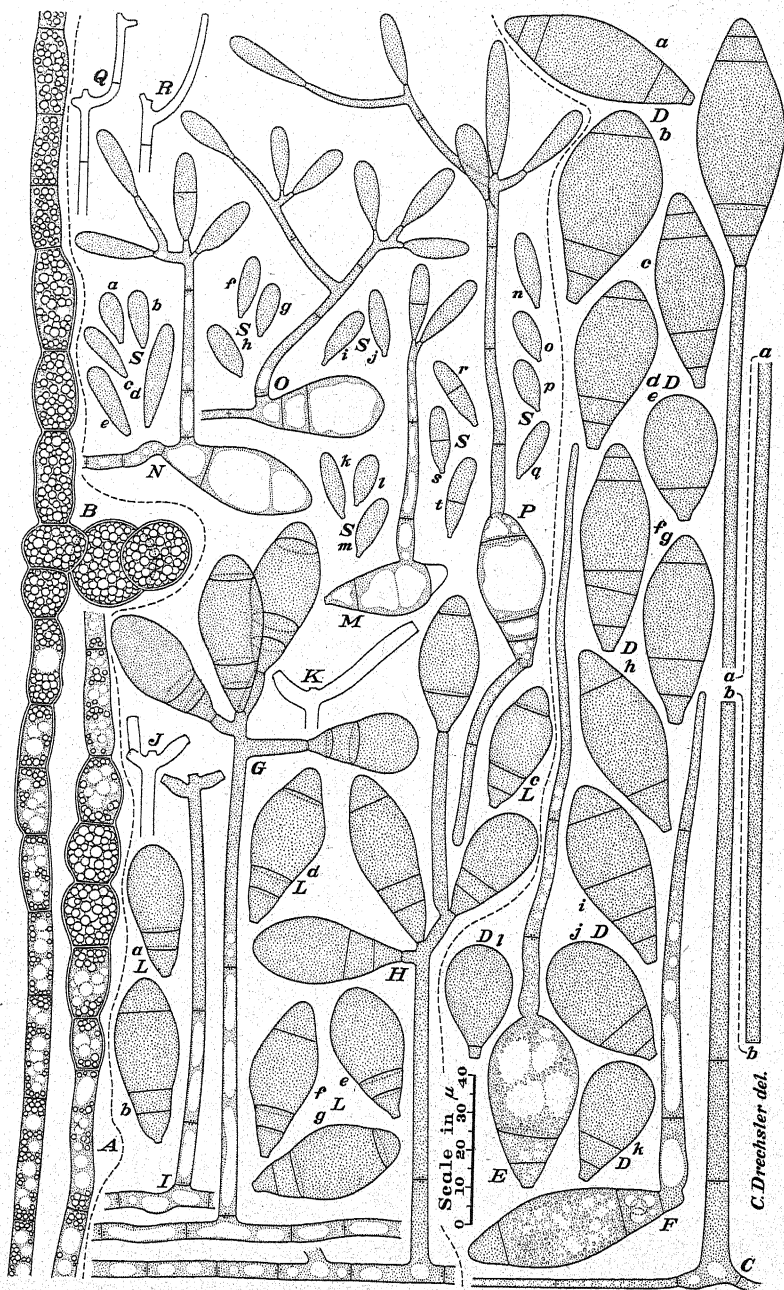


FIG. 4. A, B, *Arthrobotrys arthrobotryoides*; C-F, *Dactylaria psychrophila* (typical strain); G-S, *Dactylaria psychrophila* (aberrant strain).

Mycelium spreading; vegetative hyphae hyaline, septate, mostly 2 to 6  $\mu$  wide, often, especially in the presence of nematodes, giving rise to hyphal bails and loops which though at first discrete are later usually compounded into more or less extensive networks; the bails and networks capturing nematodes through adhesion and entanglement, perforating the integument of each animal and intruding one or more mortiferous excrescences from which are extended assimilative hyphae to appropriate the fleshy contents. Conidiophores hyaline, erect, septate, mostly 150 to 500  $\mu$  high, 5 to 9  $\mu$  wide at the base, 2.5 to 4.5  $\mu$  wide at the tip, sometimes simple and sometimes bearing near the tip a branch (occasionally 2 branches) up to 35  $\mu$  long, often on giving rise terminally to 1 or 2 conidia elongating once or twice to produce 1 or 2 additional conidia, and thus frequently coming to bear 3 or 4 conidia in a loose head. Conidia hyaline, ellipsoidal or fusoid-ellipsoidal, rounded at the distal end, somewhat truncate at the proximal end, when developed under favorable conditions measuring mostly 46 to 71  $\mu$  (average 62.3  $\mu$ ) in length and 21 to 29  $\mu$  (average 24.7  $\mu$ ) in greatest width, containing from 1 to 5 cross-walls but mostly divided by 3 or 4 cross-walls into 4 or 5 cells whereof one, as a rule—the penultimate cell usually in triseptate specimens and the median cell usually in quadrisepate specimens—greatly exceeds the others in size.

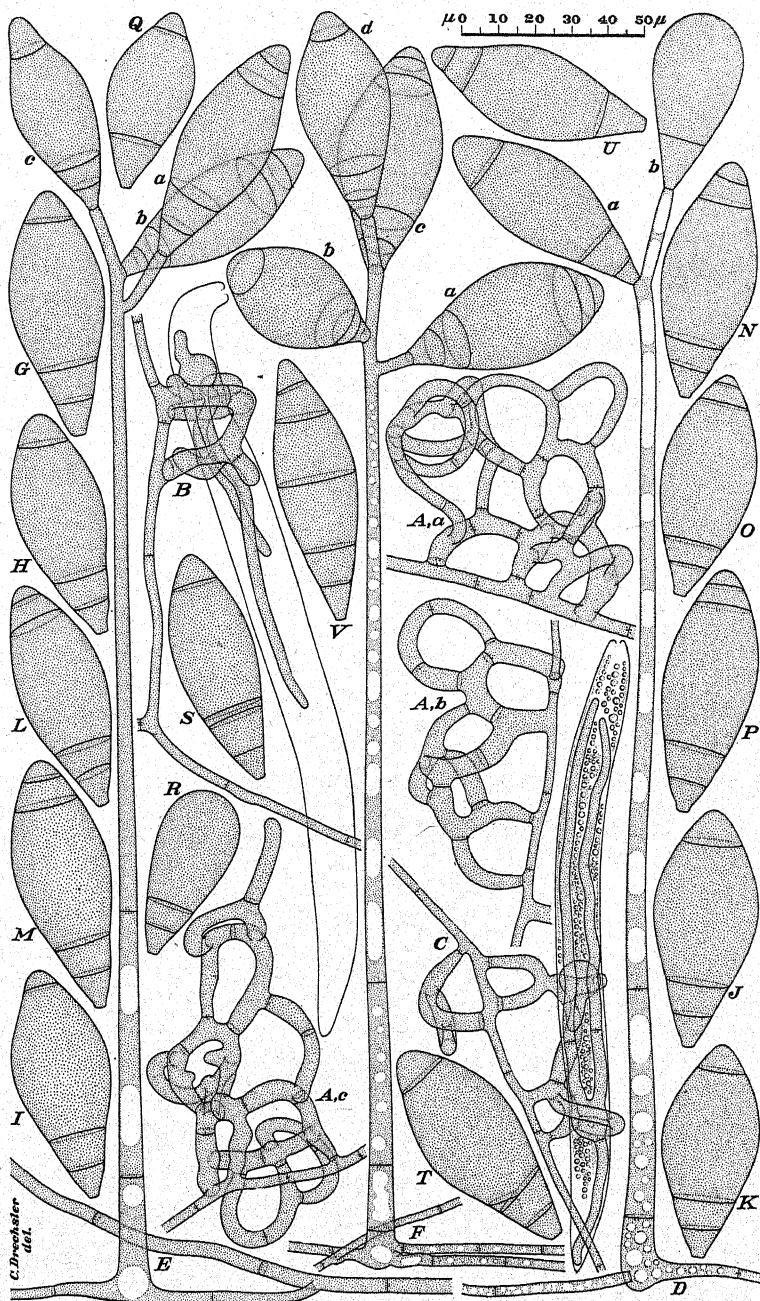
Capturing and consuming eelworms that measure usually 150 to 600  $\mu$  in length and that belong to species of *Acroboloides*, *Cephalobus*, *Plectus*, *Rhabditis*, and other genera, it occurs on decaying leaves and stems of *Solanum tuberosum* L. near Presque Isle, Maine.

A SECONDARY CONIDIAL STAGE APPARENTLY REFERABLE TO  
DACTYLARIA PSYCHROPHILA

Although the foregoing account of *Dactylaria psychrophila* is based primarily on study of a single culture, it applies equally well to more than a dozen other cultures, similar in behavior and morphology, that were derived from other specimens of decaying potato vines also collected near Presque Isle, Me., on Oct. 2, 1941. Mention must be made, however, of differences noted in an aberrant culture isolated from the same general collection of old potato vines. Under congenially cool conditions and on suitable substrata, the strain in question shows very satisfactory agreement with the other strains; but when unfavorably high

temperatures supervene it responds by even more pronounced shortening of the conidiophores, which, as a result, then often bear their first conidia at heights between 80 and 130  $\mu$  (FIG. 4, G, H, I). Plural production of conidia in loose heads (FIG. 4, G, H), following subapical branching or prolongation of the supporting hyphae (FIG. 4, I-K), continues with little abatement, but rather generally the conidia then formed measure only 30 to 50  $\mu$  in length and 15 to 20  $\mu$  in greatest width (FIG. 4, L, a-g). Premature germination, while the conidia are still attached, occurs only rarely. In aging maize-meal-agar plate cultures, especially in cultures where species of *Penicillium* have partly overgrown the substratum, a fallen conidium often puts forth an erect or ascending germ-conidiophore, which may be simple (FIG. 4, M), or somewhat branched (FIG. 4, N, O), or successively prolonged (FIG. 4, P). On these germ-conidiophores are frequently borne 4, 5, or 6 secondary conidia, mostly elongate ellipsoidal or elongate obovoid in shape, and often drawn out noticeably at the basal end. Varying in length from 14 to 35  $\mu$ , and in width from 4.8 to 7.5  $\mu$ , the secondary conidia are much smaller than the primary spores that produce them. While most of them evidently remain continuous (FIG. 4, S, a-g), some become divided by a median septum (FIG. 4, S, r-t).

Conidial apparatus closely resembling the subsidiary reproductive stage just described came to light in a maize-meal-agar plate culture planted with leaf mold taken from deciduous woods near Presque Isle, Me., on Oct. 2, 1941. A tract about 25 square millimeters in extent adjoining the deposit of forest refuse afforded development of a sparse mycelium consisting of colorless septate filaments mostly 2.5 to 3  $\mu$  in width. From these filaments, not any of which were supplied with predaceous organs, arose hyaline, meagerly septate, tapering, erect hyphae, mostly 50 to 90  $\mu$  high, 4 to 5  $\mu$  wide at the base and 1.5 to 2.5  $\mu$  wide near the tip, where they gave off usually 1 to 3 lateral spurs (FIG. 3, C-E; F, a, b; G, a, b). As the axial tip and each of the spurs supported a conidium, most of the erect hyphae bore aloft 2, 3, or 4 conidia in loose capitate arrangement. These conidia were of elongate ellipsoidal or elongate obovoid shape, and usually tapered noticeably toward the blunt narrow basal end. They measured from

FIG. 5. *Dactylaria psychrophila* (typical strain).

16 to 27  $\mu$  in length and from 5.4 to 7.2  $\mu$  in greatest width. Though they were predominantly unseptate in their definitive state (FIG. 3, *H*, *a-z*; *I*, *a-j*), some of them became partitioned by a median cross-wall (FIG. 3, *K*, *k-q*).

Owing in part to the low stature of the sporiferous hyphae and their tendency to collapse rather quickly on exposure to normal evaporation, efforts to isolate the fungus by aseptic removal of conidia proved unsuccessful. Consequently it remains uncertain whether the modest conidial apparatus represented the principal reproductive stage of a small hyphomycete, or an accessory stage of some relatively large mucedinaceous form. That it may belong to *Dactylaria psychrophila* is suggested by its occurrence in decaying vegetable material collected in the same locality at the same time, and by the resemblance of its conidia to the secondary conidia formed occasionally in the aberrant strain of the very robust nematode-capturing hyphomycete.

#### A KNOBBED NEMATODE-CAPTURING HYPHOMYCETE WITH A TRICHOTHECIUM STAGE

A similarly perplexing fungus appeared in a maizemeal-agar plate culture which after being permeated with *Pythium* mycelium had been further planted with leaf mold collected in deciduous woods near Fairfax, Va., on Nov. 10, 1942. Its straightforward, sparingly branched, colorless, vegetative hyphae, septate at intervals of 15 to 35  $\mu$ , and measuring 2 to 2.4  $\mu$  in width, bore globose cells, mostly 5.8 to 7.2  $\mu$  in diameter, on stalks 1.5 to 5  $\mu$  long and 2 to 2.5  $\mu$  wide (FIG. 3, *J*, *a-e*). The resemblance of these globose cells to the adhesive predaceous organs of *Dactylella ellipsospora* and of the two allied species I have described as *Dactylella asthenopaga* (4, p. 496-499) and *Dactylaria haptospora* (5, p. 456-461) identified them unmistakably as organs for capture of nematodes, though, owing very probably to scarcity of suitable prey, nematodes were not actually seen captured by them. Apart from the predaceous structures formed on the surface of the substratum as well as in submerged positions, the mycelial filaments were found bearing a sparse array of colorless, sparingly septate, erect, tapering conidio-



phores often 35 to 65  $\mu$  high, 2 to 3.5  $\mu$  wide at the base, and 1 to 1.5  $\mu$  wide at the tip. In many instances these conidiophores showed no branching, though rather often, after they had produced a single spore at the tip and had fallen over on the substratum, they would give rise from one of their basal cells to a new conidiophore. Now and then, however, a conidiophore (FIG. 3, *J, f*) would give off one or even two fertile branches (FIG. 3, *J, g, h*) while still in an erect posture. The conidia were generally of elongate ellipsoidal shape, with the distal end bluntly rounded and the basal end perceptibly truncate (FIG. 3, *K, a-h*). They measured mostly 17 to 27  $\mu$  in length by 4.2 to 5.6  $\mu$  in greatest width, and were consistently divided by a single cross-wall at the middle or slightly above the middle.

As all efforts to isolate the fungus by aseptic removal of bacterium-free conidia proved unsuccessful, it has not been possible to determine whether the reproductive apparatus found associated with the knob-bearing mycelium is to be considered a primary sporulating stage or a subsidiary stage. *Dactylella ellipsospora*, the most frequent of the 3 species known to form predaceous organisms of the type here in question, had developed abundantly in the same culture, though no hyphal connection with it could be discovered. The globose cells appeared, in general, somewhat smaller than those characteristic of *D. ellipsospora*; so that with respect to size they more closely resembled the predaceous organs of *Dactylella asthenopaga* and *Dactylaria haptospora*. The latter two species, however, were not observed in the same culture with the fungus under discussion, nor, for that matter, in any of the several dozen other cultures planted with material from the same collection of leaf mold. Nothing that could be taken for a subsidiary sporulating stage has ever been noted in my pure cultures of *D. ellipsospora*, *D. asthenopaga*, and *D. haptospora*.

If the conidial apparatus under discussion should represent a primary sporulating stage, as seems not unlikely, the fungus would be properly referable to *Trichothecium*. In this genus it would offer close similarity to *T. arrhenopum*, a delicate species I have recently described (7) as a destructive parasite on oospores



of *Pythium graminicolum* Subr. With respect to natural relationship it appears far removed from the widely familiar *T. roseum* Link.

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#### EXPLANATION OF FIGURES

FIG. 1. *Arthrobotrys cladodes* var. *macroides*; drawn with the aid of a camera lucida to a uniform magnification;  $\times 500$  throughout. A, B, Portions of mycelial filament, on each of which a predaceous network has been produced. C, Portion of mycelium with a predaceous network that has been operative in capturing a nematode referable to *Acrobeloides* sp.; from the 3 bulbous enlargements intruded into the animal to disable its assimilative hyphae have grown lengthwise through the fleshy interior. D, Portion of prostrate hypha with 2 conidiophores, one of which, *a*, is shown with its cluster of conidia attached, while the other, *b*, a distally branched specimen whereon 2 clusters had been borne, is shown in a denuded state. E, Portion of prostrate hypha that has given rise to 3 conidiophores; the conidiophore *a*, bearing a subapical branch, is shown with its 2 clusters of conidia attached, while the simple conidiophores, *b* and *c*, are shown denuded of their spores. F, Portion of prostrate hypha bearing an unusually short conidiophore.

G, Portion of prostrate hypha with a denuded conidiophore bearing a sub-apical branch rather markedly expanded at its tip. H, Denuded terminal portions of conidiophores, *a-e*, showing arrangement of the denticulations on which the conidia were borne. I, J, Assortment of conidia, *a-z*, showing variations in shape, in size, and in position of the cross-wall. K, Conidia, *a-d*, germinating by emission of a basal germ tube. L, Three pairs of conidia, *a-c*, united by vegetative anastomoses. M, Conidium anastomosed with a mycelial filament. O, Vegetative hypha, with small vacuoles beginning to form within cellular contents otherwise nearly homogeneous in appearance. P, Strongly vacuolate enlarged hypha with some accumulation of small globules. Q, Branched portion of mycelial hypha with more pronounced accumulation of small globules. R, Resting body consisting of 11 cylindrical cells and 1 strongly inflated cell. S, T, U, Resting bodies with their component cells more or less strongly inflated and filled with relatively large globules.

FIG. 2. *Arthrobotrys arthrobotryoides*; drawn with the aid of a camera lucida to a uniform magnification;  $\times 500$  throughout. A, Portion of mycelial hypha on which a small predaceous network has been formed. B, Portion of mycelial hypha that has produced a somewhat extensive network, *a*, as well as a smaller network, *b*, compounded of only 4 bail-like elements. C, Portion of mycelial filament with a small predaceous network that has been operative in capturing a nematode referable to *Acrobeloides* sp.; the mortiferous enlargement from which 3 assimilative hyphae have grown through the fleshy interior was intruded directly from the inner aspect of an enveloping bail-like element, the narrow communication through the perforated integument being shown in profile. D, Portion of mycelial filament with a small predaceous network that has been operative in capturing a nematode belonging to *Acrobeloides* sp.; the 2 mortiferous enlargements whereby the animal was disabled were intruded from 2 short branches which manifestly grew firmly against the animal after its capture; only the larger of the mortiferous bodies—the one from which 2 assimilative hyphae were extended toward the tail end—is shown connected in profile view with the external branch from which it originated. E, Conidiophore with 10 conidia borne in the typically monocephalous arrangement usual in nematode-infested cultures. F, Denuded conidiophore from a nematode-infested culture; for lack of space it is shown in 3 portions separated at the cross-walls *a* and *b*. G, Portion of a fasciated mycelial strand formed aerially in pure culture under humid conditions; from the component hypha shown uppermost are given off 2 conidiophores; one of the conidiophores, *a*, bears 20 conidia in 4 clusters so indistinctly separated as to present the appearance of botryose arrangement; the other conidiophore, *b*, shows in its denuded state similarly indistinct separation of its 4 denticulate nodes. H, I, J, Denuded conidiophores from a pure culture, showing arrangement of denticulations on the prolonged axis. K, L, Somewhat branched distal portions of denuded conidiophores that developed in a pure culture on maize meal agar under humid conditions. M, Random assortment of conidia, *a-q*, from a nematode-infested culture kept at about 20° C., showing normal variation in size, in shape, and in position of cross-wall. N, Assortment of conidia, *a-p*, developed in pure culture under humid conditions at a temperature of about 20° C.; some of the spores (*c*, *g*, *n*) illustrate rather extreme variations in shape, in size, or in position of septum.

FIG. 3. Drawn with the aid of a camera lucida to a uniform magnification;  $\times 500$  throughout.

*A, B, Arthrobotrys arthrobotryoides*: *A*, Assortment of uniseptate conidia, *a-z*, formed in pure culture on maize meal agar at temperatures varying mostly between  $28^{\circ}$  and  $32^{\circ}$  C. *B*, Assortment of uniseptate conidia, *a-j*, formed likewise at temperatures between  $28^{\circ}$  and  $32^{\circ}$  C.

*C-I*, Sporulating stage possibly belonging to *Dactylaria psychrophila*: *C, D, E*, Portions of prostrate hyphae, each with a conidiophore; on the conidiophores are borne, respectively, 2, 3, and 4 conidia. *F*, Portion of a prostrate hypha from which has arisen a young conidiophore, *a*, bearing only a single conidium, and a slightly older conidiophore, *b*, bearing 2 conidia. *G*, Portion of a prostrate hypha with a rather young conidiophore, *a*, bearing 2 spores, and a somewhat older conidiophore, *b*, bearing 3 spores. *H*, Uniseptate conidia, *a-z*, showing variations in size and shape. *I*, Assortment of conidia including some continuous specimens, *a-j*, and some uniseptate specimens, *k-q*.

*J, K*, Predaceous knob-bearing fungus with delicate *Trichothecium* stage: *J*, Portion of mycelial filament bearing 5 predaceous knob-like organs, *a-e*, and a conidiophore, *f*, with 2 branches, *g* and *h*. *K*, Assortment of conidia, *a-h*, showing normal variations in size, in shape, and in position of cross-wall.

FIG. 4. Drawn with the aid of a camera lucida to a uniform magnification;  $\times 500$  throughout.

*A, B, Arthrobotrys arthrobotryoides*: *A*, Somewhat immature resting body from a maize meal-agar plate culture 3 months old. *B*, More nearly mature resting body from same culture.

*C-F, Dactylaria psychrophila* (typical strain): *C*, Conidiophore bearing only a single conidium, as found frequently in nematode-infested cultures. *D*, Assortment of conidia, *a-l*, formed in a maize meal-agar plate culture kept at temperatures between  $28^{\circ}$  and  $32^{\circ}$  C. *E*, Conidium with an apical germ tube, as often found while still attached to the conidiophore in cultures kept at  $28^{\circ}$  to  $32^{\circ}$  C. *F*, Conidium germinating after falling on moist substratum.

*G-S, Dactylaria psychrophila* (aberrant strain): *G, H*, Conidiophores, each bearing 4 conidia, from a pure culture on maize meal agar grown at temperatures between  $28^{\circ}$  and  $32^{\circ}$  C. *I*, Denuded conidiophore from same culture. *J, K*, Distal portions of denuded conidiophores likewise from same culture. *L*, Assortment of conidia, *a-g*, from same culture. *M-P*, Conidia which, after falling on the surface of a 40-day-old maize meal-agar plate culture contaminated with *Penicillium* sp., have given rise to erect or ascending germ conidiophores whereon are borne a number of smaller secondary conidia. *Q, R*, Denuded distal portions of germ conidiophores. *S*, Random assortment of secondary conidia, showing normal variations in size and shape; with the more numerous continuous specimens, *a-q*, are included a few uniseptate specimens, *r-t*.

FIG. 5. *Dactylaria psychrophila* (typical strain) as found in cultures kept at temperatures near  $17^{\circ}$  C.; drawn with the aid of a camera lucida to a uniform magnification;  $\times 500$  throughout. *A*, Portions of hyphae, *a-c*, on each of which a predaceous network has been produced. *B*, Portion of mycelial filament with a predaceous network that has been operative in the capture of an eelworm referable to *Acrobeloides* sp.; 3 assimilative hyphae are being extended into the fleshy interior from the single mortiferous enlargement

intruded by one of the 2 short branches that grew firmly against the animal after its capture. *C*, Portion of mycelial hypha with a predaceous network that has been operative in the capture of an eelworm referable to *Acrobeloides* sp.; 2 mortiferous enlargements are visible within the integument, the one shown uppermost having been intruded from a hyphal branch curving only half-way around the animal, the other, nearer the tail, having been intruded from an enveloping loop; the second and older of the globose enlargements has given rise to 3 assimilative hyphae whose advance lengthwise through musculature and organs has resulted in globulose degeneration of the invaded parts. *D*, Conidiophore which after giving rise on its original apex to the conidium *a* resumed growth to produce a second conidium, *b*, on its new apex. *E*, Conidiophore with a short subapical spur on which the conidium *a* has been produced; on the original tip of its main axis it first gave rise to the conidium *b*, and then resumed growth to form the conidium *c* on a new apex. *F*, Conidiophore which, apart from producing the conidium *a* on a short subapical spur, has given rise on its axial hypha first to the conidium *b*, and then in succession, with repeated renewal of growth, to the conidia *c* and *d*. *G-P*, Representative assortment of conidia showing normal variations in size, in shape, and in partitioning with 3 or 4 cross-walls. *Q-V*, Conidia showing more unusual partitioning by cross-walls varying in number from 2 to 5.

## NOTES ON OKLAHOMA CERCOSPORAE—III

W. WINFIELD RAY

Thirty-seven species of *Cercospora*, nine of which were described as new, have been recorded for Oklahoma since 1940.<sup>1</sup> Recent collections taken principally in 1942 have been sent for examination to Dr. C. D. Chupp, who discovered four new species among them.

At the request of Dr. Chupp, who very generously suggested the names and technical diagnosis, the following new species are herein described:

### 1. *Cercospora Gomphrenae* sp. nov.

Maculis orbicularibus, 0.5–4 mm. diam., alutaceis vel sordide cinereis, zona lata rubra vel purpurea restrictis; fungis amphigenis; stromatibus irregularibus, parvis, cellis paucis vel  $35\ \mu$  longis, atro-fuligenis; fasciculis cum 4–20 conidiophoris divaricatis; conidiophoris in masse mediocriter nigris, singulatis dilute-fuligenis, apicibus pallidioribus et angustioribus, indistincte pluriseptatis, non-ramosis, rectis vel diverse curvatis, plerumque non-geniculatis, cicatricibus sporarum mediocribus ad apicibus subtruncatis,  $4\text{--}5.5 \times 30\text{--}150\ \mu$ , plerumque  $50\text{--}90\ \mu$ ; conidiis hyalinis, acicularibus, rectis vel leviter curvatis, indistincte pluriseptatis, ad bases truncatis, ad apices acutis,  $2\text{--}3.5 \times 30\text{--}135\ \mu$ .

Leaf spots circular, 0.5–4 mm. in diameter, tan to dingy gray, bordered by a wide red to purplish zone; fruiting amphigenous, stromata irregular, small, ranging from a few cells to  $35\ \mu$  in length, dark fuliginous; fascicles 4 to 20 divergent stalks; conidiophores in mass fairly dark, singly pale fuliginous, tips paler and narrower, indistinctly multiseptate, not branched, straight to variously curved, mostly not geniculate, medium spore scar at the subtruncate tip,  $4\text{--}5.5 \times 30\text{--}150\ \mu$ , mostly  $50\text{--}90\ \mu$ ; conidia hyaline, acicular, straight to slightly curved, indistinctly multiseptate, bases truncate, tips acute,  $2\text{--}3.5 \times 30\text{--}135\ \mu$ .

HABIT: On leaves of *Gomphrena globosa* L., Stillwater, Oklahoma, August 18, 1942. This species is distinct from other Cercosporae with acicular conidia on the Amarantaceae.

<sup>1</sup> Ray, W. Winfield. (Papers on Oklahoma *Cercosporae*.) Mycologia 32: 271. 1940; 33: 174–177. 1941; 34: 558–562. 1942.

TYPE: In the herbarium of the Department of Plant Pathology, Cornell University, No. 33132.

## 2. *Cercospora Gonolobi* sp. nov.

Maculis irregularibus, olivaceis vel cinereis vel atro-brunneis vel pustulis nigris, 2–14 mm. in spatio vel aliquando in areas magnas confluentibus, margine distincto egentibus; fungis amphigenis sed amplioribus in superiore superficie; stromatibus atro-brunneis, globosis, 20–40  $\mu$  vel raro tenuis 75  $\mu$ ; plerumque fasciculis densis, raro densissimis; conidiophoris pallidis vel mediocriter olivaceo-brunneis, apicibus pallidioribus et saepe leviter tumidis, cicatricibus sporarum parvis 1 vel 2, 1–6 septatis, parce ramosis, undulatis, 1–3 geniculatis, 3–4.5  $\times$  10–80  $\mu$ ; conidiis obclavatis vel cylindro-obclavatis, rectis vel paene, subhyalinis vel dilute olivaceis, septis inconspicuis, ad bases obconico-truncatis vel globosis, ad apices obtusis, 4–5  $\times$  30–80  $\mu$ .

Leaf spots irregular, olivaceous to gray or dark brown to black blotches, 2–14 mm. in extent or sometimes coalescing into large areas, distinct border lacking; fruiting amphigenous but more abundant on the upper surface; stromata dark brown, globular, 20–40  $\mu$  or rarely elongated to 75  $\mu$ ; fascicles mostly dense, rarely very dense; conidiophores pale to medium olivaceous brown, tips somewhat paler and often slightly swollen, 1 or 2 small spore scars, 1–6 septate, sparingly branched, undulate, or 1–3 geniculate, 3–4.5  $\times$  10–80  $\mu$ ; conidia obclavate to cylindro-obclavate, straight to nearly so, subhyaline to pale olivaceous, septa not distinct, bases obconically truncate to rounded, acute tips, 4–5  $\times$  30–80  $\mu$ .

HABIT: On leaves of *Gonolobus laevis* Michx., Stillwater, Oklahoma, August 18, 1942. The first known collection of this fungus was made by George M. Reed at Columbia, Mo., October 1, 1910. The specimen was deposited in the herbarium at the University of Wisconsin. A description of the fungus has not previously been published.

TYPE: In the herbarium of the Department of Plant Pathology, Cornell University, No. 33133.

## 3. *Cercospora Paspali* sp. nov.

Maculis ovatis vel linearibus, maximis 5  $\times$  12 mm., atro-brunneis vel prope nigris, cerebro cum centris angustissimis et alutaceis; fungis amphigenis; stromatibus cellis paucis tenuis 30  $\mu$  diam., atro-brunneis; fasciculis cum 2–15 conidiophoris divaricatis; conidiophoris mediocriter brunneis sed ad apices pallidioribus et distincte attenuatis, 2–5 septatis, parce geniculatis, rectis vel tortuosis, non-ramosis, cicatricibus sporarum mediocribus ad apicibus sub-

truncatis,  $3-4.5 \times 10-80 \mu$ ; conidiis hyalinis, acicularibus vel prope cylindris, rectis vel nonnihil curvatis vel undulatis, indistincte pluriseptatis, ad bases truncatis vel obconico-truncatis, ad apices subacutis vel subobtusis,  $1.2-4 \times 30-140 \mu$ .

Leaf spots oval to linear, the largest attaining  $5 \times 12$  mm., dark brown to almost black, frequently with very narrow tan centers; fruiting amphigenous; stromata a few cells to  $30 \mu$  in diameter, dark brown; fascicles 2-15 divergent stalks; conidiophores moderately brown but paler and distinctly attenuated toward the tips, 2-5 septate, sparingly geniculate, straight to tortuous, not branched, medium spore scar at the narrow subtruncate tip,  $3-4.5 \times 10-80 \mu$ ; conidia hyaline, narrowly acicular to almost cylindric, straight to slightly curved or undulate, indistinctly multiseptate, truncate to obconically truncate at the bases, subacute to subobtuse at the apices,  $1.2-4 \times 30-140 \mu$ .

HABIT: On leaves of *Paspalum stramineum* Nash, Perkins, Oklahoma, August 26, 1942. Perhaps this same species was collected by Hansford in Uganda, East Africa, on *P. scrobiculatum* L. No previous technical diagnosis, however, has been published.

TYPE: In the herbarium of the Department of Plant Pathology, Cornell University, No. 33134.

#### 4. *Cercospora Staphyleae* Ray & McLaughlin, sp. nov.

Maculis suborbicularibus vel angularibus, 0.5-4 mm. diam., cinereis vel albis, marginibus latis et atro rubro-brunneis, in inferiore superficie minus distinctis; fungis amphigenis; stromatibus atro-brunneis, globosis, cellis paucis grandis tenuis  $25 \mu$  diam.; fasciculis cum 2-12 conidiophoris divaricatis; conidiophoris mediocriter brunneis sed proxime apicibus leviter pallidioribus, juste uniformibus in diametro, pluriseptatis, non-ramosis, rectis vel nonnihil curvatis, parce geniculatis, cicatricibus sporarum mediocribus ad apicibus subtruncatis,  $4-6 \times 30-150 \mu$ ; conidiis hyalinis, acicularibus vel per occasionem obclavatis, ad bases truncatis vel subtruncatis, ad apices acutis,  $2-4 \times 30-150 \mu$ .

Leaf spots subcircular to angular, 0.5-4 mm. in diameter, gray to white, with wide dark reddish brown margins, less distinct on the lower surface of the leaf; fruiting amphigenous; stromata dark brown, globular, a few large cells to  $25 \mu$  in diameter; fascicles 2-12 divergent stalks; conidiophores medium brown but slightly paler near the tips, fairly uniform in diameter, multiseptate, not branched, straight to mildly curved, sparingly geniculate, medium spore scar at the subtruncate tip,  $4-6 \times 30-150 \mu$ ; conidia

hyaline, acicular or occasionally obclavate, straight to slightly curved, indistinctly multiseptate, truncate to subtruncate at the bases, tips acute  $2-4 \times 30-150 \mu$ .

HABIT: On leaves of *Staphylea trifolia* L., Stillwater, Oklahoma, September 17, 1942.

TYPE: In the herbarium of the Department of Plant Pathology, Cornell University, No. 33135.

5. *Cercospora daturicola* (Speg.) comb. nov.

*Cercosporina daturicola* Speg. Anal. Mus. Nac. B. Aires 20: 425. 1910.

*Cercospora abchazica* Siemaszko, Bul. du Musée du Caucase 12: 27. 1919.

The collection (No. 2877) of this fungus was made at Pleasant Valley, Oklahoma, on September 1, 1942. According to Dr. Chupp this is probably the first report for North America. There appears to be some doubt concerning the presence of the TYPE specimen, but it may be in the collections of Spegazzini in the Museo Spegazzini, La Plata, Argentina, South America.

The Oklahoma collection is as described by Spegazzini for *Cercosporina daturicola*, except for a discrepancy with regard to the conidia. Those of our specimen are for the most part distinctly 6-7 septate, whereas Spegazzini describes them as having 3.

A specimen is deposited in the herbarium of the Department of Plant Pathology, Cornell University as No. 33131.

The following recent collections of Cercosporae are deposited in the Cryptogamic Herbarium at the Oklahoma A. & M. College:

6. *Cercospora Arcti-Ambrosiae* Halsted.

On *Ambrosia trifida* L., Perkins, Aug. 20, 1942, No. 2878.

Halsted's species is rare on this host.

7. *Cercospora biformis* Peck.

On *Passiflora incarnata* L., McAlester, Aug. 27, 1942, No. 2879 and Stillwater, Sept. 17, 1942, No. 2880.

8. *Cercospora Celosiae* Sydow.

On *Celosia argentea* L., Stillwater, Aug. 18, 1942, No. 2881.

First report for North America; previously reported only from China, Brazil, and Venezuela.



9. *Cercospora Cephalanti* Ellis & Kellerm.  
On *Cephalanthus occidentalis* L., Stillwater, Sept. 17, 1942.  
No. 2882.
10. *Cercospora Chrysanthemi* Heald & Wolf.  
On *Chrysanthemum maximum* Ram., Stillwater, Aug. 18,  
1942, No. 2883.
11. *Cercospora condensata* Ellis & Kellerm.  
On *Gleditsia tricanthos* L., Stillwater, Sept. 1, 1943, No. 2916.
12. *Cercospora sojina* Hara syn. *Cercospora daizu* Miura  
On *Soja Max* (L.) Piper, Stillwater, Sept. 9, 1943, No. 2924.  
In American literature *C. daizu* has been misspelled.
13. *Cercospora Diodiae* Cooke.  
On *Diodia teres* Walt., Perkins, Aug. 20, 1942, No. 2884.
14. *Cercospora glandulosa* Ellis & Kellerm.  
On *Ailanthus glandulosa* Desf., Stillwater, Aug. 24, 1942,  
No. 2886.
15. *Cercospora Lycii* Ellis & Kellerm.  
On *Lycium pallidum* Miers., Stillwater, Sept. 17, 1942,  
No. 2889.
16. *Cercospora personata* (B. & C.) Ellis & Ev.  
On *Arachis hypogaea* L., Holdenville, Aug. 27, 1942, No.  
2890.
17. *Cercospora Physocarpi* Ray.  
On *Spiraea japonica* L., Stillwater, Aug. 18, 1942, No. 2896.  
A new host record for this fungus.
18. *Cercospora rhoina* Cooke & Ellis.  
On *Rhus glabra* L., Stillwater, Aug. 18, 1942, No. 2894.
19. *Cercospora salviicola* Tharp.  
On *Salvia azurea* Lam., Stillwater, Aug. 26, 1942, No. 2895.

OKLAHOMA A. & M. COLLEGE,  
STILLWATER

# A BIBLIOGRAPHICAL STUDY OF THE ICONES PICTAE SPECIERUM RARIORUM FUNGORUM OF CHRISTIAAN HENDRIK PERSOON

HARRY MORTON FITZPATRICK

(WITH 4 FIGURES)

Adoption of the *Synopsis Methodica Fungorum*, by the International Botanical Congress, as the starting point for nomenclature of the Ustilaginales, Uredinales and Gasteromycetes has caused that book to be more widely used in recent years than any other of Persoon's publications. The companion volume of hand colored plates prepared by him to illustrate some of the less common species described in the *Synopsis* is, in comparison, little known. This book bears the double title *Icones Pictae Specierum Rariorum Fungorum in Synopsi Methodica Descriptarum a C. H. Persoon*.—*Figures Coloriées des Espèces Rares des Champignons Décrits dans l'Ouvrage Intitulé: Synopsis Methodica Fungorum par C. H. Persoon*. It was published in four fascicles, each consisting of six plates with accompanying descriptive matter printed largely in duplicate in Latin and French. The entire work was published by Amand Koenig at Paris and Strasbourg.

For several reasons, this book has unusual bibliographical interest. It is one of Persoon's rarer works; to a surprising degree, copies of it have been preserved in an incomplete condition; and, quite generally, the date of publication of the last fascicle has been recorded incorrectly. We are concerned in this paper only with such bibliographical matters. Our statements are based on a critical study of the known copies of the work in North American libraries. It has been our privilege to examine several of them, and detailed knowledge of the others has been gained through correspondence. In the endeavor to locate as many specimens of the book as possible, and obtain information as to their state of completeness, a brief questionnaire was sent to a carefully selected list of mycologists and institutional libra-

rians. The response was very gratifying, and brought to our attention more than a dozen copies of which we had not previously known. This survey has been confined to the United States and Canada. We have little information concerning the work in libraries abroad.

Our interest in this rare old book was aroused by the discovery that the copy in the Cornell University library lacked the entire fourth fascicle, had no title page, and was incomplete in additional minor respects. Realizing that the missing portions could be photographed, and in particular that the colored plates could be reproduced by means of the recently developed processes of color photography, we borrowed another copy and set about completing our own. Having learned, meanwhile, of the existence of several other specimens of the book, also lacking the fourth fascicle, we placed a note in *Mycologia* (35: 256-257. 1943) in which we offered to prepare sets of prints for completion of such imperfect copies.<sup>1</sup>

Each of the four fascicles comprising the volume was provided originally with a cover of heavy gray or blue paper. The first page of the cover, in each instance, bears the complete title of the work in duplicate in Latin and French, carries the date and place of publication of the fascicle and gives the name of the publisher (FIG. 1). The second page bears a brief advertisement (FIG. 2), while the third is blank. The fourth provides a table of contents and an imprint giving the name and address of the printer (FIG. 3). As none of the material on these covers was


<sup>1</sup> All the photographs, except the two reproduced here as figure 1 and figure 3, were made by Mr. Willis R. Fisher of the Department of Plant Pathology at Cornell University. He has had years of experience in photographing botanical materials, and has been keenly interested in the preparation of colored prints from wash-off relief film. He is also skillful in hand-coloring ordinary prints. Both methods have been used by him in copying these colored plates. His prints match the original pages in size, and are wholly suitable for binding with them. Pages 45-64 and plates 19-24, comprising fascicle 4, all the pages of the four covers, and all the known half-title pages have been photographed. Though wartime limitations on photographic materials have handicapped us, we have been able to supply the missing pages for insertion in practically all of the known North American copies of this valuable old book. More than three hundred prints were required. We have completed seven copies which lacked the entire fourth fascicle, and have provided the various missing cover pages and half-title pages in the others.

ICONES PICTÆ  
SPECIERUM  
RARIORUM FUNGORUM

IN  
SYNOPSIS METHODICA DESCRIPTARUM

A  
C. H. PERSOON.

FASCICULUS QUARTUS



FIGURES COLORIÉES  
DES ESPECES RARES

DES  
CHAMPIGNONS

DÉCRITS DANS L'OUVRAGE INTITULÉ:  
SYNOPSIS METHODICA FUNGORUM

PAR  
C. H. PERSOON.

QUATRIÈME LIVRAISON.

A PARIS et à STRASBOURG  
CHEZ AMAND KOENIG, LIBRAIRE.

1808.

FIG. 1. The first page of the colored paper cover of fascicle 4. Photograph of the copy in the Library of Congress obtained for us by John A. Stevenson. Letters actual size, but page of original is approximately  $9 \times 11$  inches.

duplicated on sheets of white paper, copies of the book in which the covers are absent lack a title page and table of contents. Other books published at that period, with successive parts issued in similar colored paper covers, commonly contain pages on which the essential material on the covers is duplicated. This is true, for example, of Persoon's *Icones et Descriptiones Fungorum Minus Cognitorum*. In such cases absence of the covers is less important.

Though the date of publication of the first fascicle of the *Icones Pictae Specierum Rariorum Fungorum* appears on the cover as "An XI—1803," that of the second as "An XII—1804" and that of the third as "An XIII—1805," it will be noted (FIG. 1) that the date of fascicle 4 reads merely "1808." These Roman numerals on fascicles 1–3 constitute reckoning in terms of the years of the French Republic which was established in 1792. As Napoleon was declared Emperor in 1804 the reason for absence of reference to the Republic on the cover of the fourth fascicle can be readily surmised.<sup>2</sup> It is possible that the political situation in France was responsible for delay in the appearance of this fascicle, which might otherwise have appeared in 1806, and its absence in so many copies of the book today may have resulted from difficulties encountered in its distribution at that unsettled period.

The year of publication of fascicle 4 has been commonly recorded in the mycological literature as 1806. Pritzel (5) gives this date in both editions of his usually dependable *Thesaurus Litteraturae Botanicae*, and Lindau and Sydow (4) do the same in their *Thesaurus Litteraturae Mycologicae et Lichenologicae*. Brunet (1) in his well known reference work, *Manuel du Libraire et de l'Amateur de Livres*, not only cites the year 1806, but also states wholly erroneously that the work contains 39 plates and was published by Treuttel and Würtz. Graesse (3) in his *Trésor de Livres Rares et Précieux ou Nouveau Dictionnaire Bibliographique* agrees with Brunet on these various points except in

<sup>2</sup> One of our correspondents has called our attention to a similar use of Roman numerals, on recent numbers of Italian publications, to record the years of Mussolini's dictatorship. His prophecy that ere long this practice also would disappear seems well on the way to fulfillment.

questioning the number of plates, which he had noted is stated by Pritzel to be only twenty-four. The catalogue card of the Library of Congress is ambiguous. Though it states that the book appeared in four parts during 1803-1806, the date of publication of the whole is given as 1808. The copy of the volume in the library of W. G. Farlow at Harvard University contains in his writing the statement that the last part appeared in 1806. That year is given also by Edith Wycoff (6), librarian of the Lloyd Library, in her Bibliography Relating to Botany Exclusive

*On trouve chez le même Libraire les Ouvrages suivans du  
même Auteur.*

Synopsis methodica fungorum, 8. Gottingæ 1801.	11 fr.
Observationes mycologicæ, cum fig. color. pars I. et II. 8. Lips. 1796-99.	22 fr.
Icones et descriptiones fungorum minus cognitorum, 4. Lips. 1798.	24 fr.
Commentatio de fungis clavæformibus, cum fig. color. 8. Lips. 1797.	8 fr.
Commentarius Schaefferi fungorum Baviariæ indigenorum icones pictas illustrans, 4. Erlangæ 1800.	9 fr. 50c.
Schaefferi fungorum qui in Bavaria et Palatinatu circa Ratisbonam nas- cuntur icones color. Editio nova, cur. Persoon, 4. Erlangæ 1800, 4 vol.	240 fr.

FIG. 2. Advertisement on page 2 of the colored paper covers of fascicles 1, 2, and 4. Reproduced here because it provides a check list of most of Persoon's other books, and is interesting in that it shows the moderate prices at which these great rarities were once sold. Two-thirds actual size.

of Floras. In her paper, Curtis G. Lloyd inserted a note which says "Persoon's *Icones Pictae Fungorum*, *Icones et Descriptiones Fungorum*, and *Observationes Mycologicæ* are among the rarest works. M. Paul Klincksieck told me that in his thirty years' search for these works he had not secured copies. The volumes in the Lloyd Library were purchased at the sale of Oudemans' books, after his death."<sup>3</sup>

A letter recently received from E. W. Mason of the Imperial Mycological Institute at Kew states that the catalogue of the library of the British Museum of Natural History gives the dates of publication of the *Icones Pictae Specierum Rariorum Fungorum* as 1803-1806. He says further that the copy of the book

<sup>3</sup> The death of Oudemans occurred in 1906.

in the library of the Royal Botanic Gardens was not acquired until 1929. These bibliographical records would seem to indicate clearly that the book is rare, and that complete copies, including the fourth fascicle, have long been comparatively unavailable for consultation.

In response to our questionnaire, which sought to determine the number and condition of copies in North American libraries, replies were received from nearly seventy-five mycologists and librarians. Though these revealed that the volume is somewhat less rare in the United States than had been supposed, the more or less incomplete condition of all the copies was a distinct surprise. Ignoring a few fragments which contain less than the first three fascicles, we have located twenty copies of the work in North America. Twelve of these have all the text and plates of the four fascicles in the original. In the other eight the whole fourth fascicle was found to be lacking.

Unfortunately, the heavy, colored paper covers, in which the fascicles were issued, were discarded in almost all cases by librarians at the time of binding. In no single specimen of the book known to us were all of them retained. In three American copies, the covers of fascicles 1-3 inclusive are intact, and in one of these the front half of the cover of the fourth fascicle is also present. This copy is at the Academy of Natural Sciences of Philadelphia, and is the most nearly complete specimen of the book thus far encountered. It is the only one in which all four title pages are present in the original. Two other copies are outstanding in being the only ones in which page 4 of the cover, bearing the table of contents, was preserved for all four fascicles.<sup>4</sup> Not one of the twelve known copies of fascicle 4 has the entire cover in which it was issued. In two of the twelve, the back portion of the cover bearing the table of contents was retained, and in two others the front portion carrying the title page was saved. One of these two examples of the title page exists in the volume in the Library of Congress; the other is that in the Academy of Natural Sciences of Philadelphia. They both un-

<sup>4</sup> In one of these copies these tables of contents were cut out of the covers and pasted side by side on a single sheet of paper. The other copy has the pages in the original condition (FIG. 3).

questionably bear the date 1808. For complete verification of the point a photograph of the title page is reproduced here (FIG. 1). We are informed by E. W. Mason that the fourth fascicle in the library of the Royal Botanic Gardens at Kew also contains this title page with the date 1808. We have no reason

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## T A B L E

<i>Aecidium aquilegiae.</i>	Aecidie de l'ancolie, page 58, planche XXIII.
<i>Aegeria pallida.</i>	Aegerite pâle, p. 50, pl. XXI.
<i>Agaricus venosus.</i>	Agaric veineux, p. 46, pl. XIX.
<i>Agaricus vulgaris.</i>	Agaric vulgaire, p. 47, pl. XIX.
<i>Diderma stellare.</i>	Diderme étoilé, p. 56, pl. XXIII.
<i>Hydnum rufescens.</i>	Hydne roussâtre, p. 45, pl. XIX.
<i>Isaria umbrina.</i>	Isarie ombrinée, p. 51, pl. XXI.
<i>Leotia mitrula.</i>	Léotie mitrulé, p. 54, pl. XXII.
<i>Peziza repanda.</i>	Pezize ondulée, p. 49, pl. XX.
<i>Physarum contextum.</i>	Physarie entrelacé, p. 55, pl. XXIII.
<i>Sphæria biformis.</i>	Sphérie biforme, p. 61, pl. XXIV.
<i>Sphæria cirrosa.</i>	Sphérie cirrheuse, p. 60, pl. XXIV.
<i>Sphæria dubia.</i>	Sphérie douteuse, p. 48, pl. XX.
<i>Sphæria fimeti.</i>	Sphérie fimétaire, p. 63, pl. XXIV.
<i>Sphæria inquinans.</i>	Sphérie noirissante, p. 62, pl. XXIV.
<i>Sphæria podoides.</i>	Sphérie podoïde, p. 59, pl. XXIV.
<i>Sphæria populina.</i>	Sphérie du peuplier, p. 52, pl. XXI.
<i>Sphæria ventricosa.</i>	Sphérie ventrue, p. 64, pl. XXIV.
<i>Stilbum citrinum.</i>	Stilbe citron, p. 53, pl. XXII.
<i>Uredo confluens.</i>	Uredo confluyente, p. 57, pl. XXIII.

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A STRASBOURG, DE L'IMPRIMERIE D'AMAND KOENIG.

FIG. 3. Table of contents on page 4 of the colored paper cover of fascicle 4. Photographed by J. T. Barrett from the University of California copy, which contains the only perfect example of this page known to us. Actual size. The imprint at the bottom shows that the fourth fascicle was printed at Strasbourg. The preceding three were printed at Paris.



to think that copies were distributed earlier, bearing the date 1806. Doubtless, the repeated mention of that year in the bibliographical literature resulted from the fact that, the first three fascicles having been published at yearly intervals from 1803 to 1805, it was assumed, in the absence of information to the contrary, that the fourth had followed in 1806.

Though no single copy of the book, as yet encountered, has been found to embrace complete specimens of all four fascicles, study of a considerable number of copies has made it possible to provide the following information with the conviction that it is correct in detail.

The first fascicle, as distributed, clearly included within its colored paper cover pages 1-14, plates 1-6 and three additional leaves. One of these extra leaves is of the nature of a binder's title page. It is printed in large letters on one side only with the following words: *Icones Pictae Rariorum Fungorum.—Figures Coloriées de Champignons Rares.* Though some librarians have used this for a title page, have written the name of the author on it, and have added information concerning the dates and places of publication, the page, as printed, bore no such data. The second leaf carries the preface, and stands between the binder's title page and the first page of the text. The prefatory material begins with the heading "Praefatio" on one side of the sheet, and ends with the words "Dabam Parisiis, mense Aprili. 1803. C. H. Persoon" on the other. The third extra leaf, bearing in large letters the words "Figures Coloriées" only, was clearly provided to stand before all the plates of the volume when these should finally be brought together at its end.

The second fascicle consisted of pages 15-28, plates 7-12, and a single additional leaf printed on one side only with the words "Figures Coloriées de Champignons Rares. Seconde Livraison" (FIG. 4). This was provided to serve as a half-title page for the fascicle.

The third fascicle included pages 29-44 and plates 13-18. Though a half-title page, bearing the words "Figures Coloriées de Champignons Rares. Troisième Livraison," should have been issued, we have failed to find a single specimen of it in any of the

twenty known American copies of the book. We now question whether the page was ever printed.<sup>5</sup>

The fourth fascicle comprised pages 45-64, plates 19-24, and a half-title page inscribed "Figures Coloriées de Champignons Rares. Quatrième Livraison."

When the four fascicles were assembled for binding as a single volume, they might well have been retained as units inside their individual covers, without rearrangement of their contents. Had this procedure been generally adopted all the uncertainty which has existed would have been avoided. Each fascicle would then

## FIGURES COLORIÉES

DE

## CHAMPIGNONS RARES.

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### SECONDE LIVRAISON.

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FIG. 4. Half-title page of fascicle 2. In the bound volume it stands properly between pages 14 and 15 of the text. Two-thirds actual size.

have had its own title page and separate table of contents. The usual method consisted, however, in assembling all the pages of the text as a single series followed by all the plates. This arrangement would have proved satisfactory also, had all the covers been retained, since the tables of contents give indication of the exact limits of the several fascicles in the text and show which plates were issued with each fascicle. The dates of publication would also have been clear. Though not wholly necessary, retention of the half-title pages to mark the line between fascicles in the text would have made further use of these items

<sup>5</sup> Our suspicion that this sheet was not issued has been strengthened on learning of its absence in a copy of fascicle 3 with uncut leaves at the University of Michigan. If the sheet is discovered by one of our readers we would appreciate greatly being informed of the fact. We should like to learn also of the location of additional copies of the book.

also. As no title page was provided to serve for the whole volume, and as there is no general index or table of contents, it was imperative that all the covers be saved. While the position of the covers in the bound volume is not of great consequence, the ideal arrangement would seem to be that in which the four title pages are grouped together preceding the text and the four tables of contents are assembled following the plates.

In order that the student desiring to consult the book may readily locate a nearby copy of it, we provide below a list of American libraries in which the volume is known to exist. The arrangement is geographical. It will be noted that the copies are located chiefly in the northeastern United States in the older institutions. We realize, of course, that the list is probably not wholly complete. In particular, it is likely that volumes in the possession of private collectors have been missed.

Massachusetts Horticultural Society, Boston, Massachusetts  
Boston Society of Natural History, Boston, Massachusetts  
Farlow Library, Harvard University, Cambridge, Massachu-  
setts

Biological Laboratories, Harvard University, Cambridge,  
Massachusetts

Brown University, Providence, Rhode Island

New York Botanical Garden, New York City

Cornell University, Ithaca, New York

Academy of Natural Sciences of Philadelphia, Philadelphia,  
Pennsylvania

Library Company of Philadelphia, Philadelphia, Pennsylvania

Library of John A. Stevenson, Beltsville, Maryland

Library of Congress, Washington, District of Columbia

University of North Carolina, Chapel Hill, North Carolina

Lloyd Library, Cincinnati, Ohio

University of Michigan, Ann Arbor, Michigan

University of Chicago, Chicago, Illinois

Missouri Botanical Garden, St. Louis, Missouri

State University of Iowa, Iowa City, Iowa

Iowa State College, Ames, Iowa

University of Minnesota, Minneapolis, Minnesota

University of California, Berkeley, California

In nineteen of these twenty copies, all four fascicles are now present. In seven of them the fourth fascicle is our photographic reproduction. The copy at the University of Michigan is in the library of Howard A. Kelly. That at the University of Minnesota is in that of E. W. D. Holway. The copy at the Academy of Natural Sciences at Philadelphia belonged earlier to B. M. Everhart, not, as might be supposed, to Schweinitz, whose herbarium is located there. Our attention has been called by Dr. F. W. Pennell to Benedict's account of Schweinitz's botanical library in Bartonian (16: 14-19. 1935) which indicates that Schweinitz did not own the *Icones Pictae* though he had four other books by Persoon. As Schweinitz and Persoon were contemporaries the point is of some interest.

CORNELL UNIVERSITY,  
ITHACA, NEW YORK

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## ALLESCHERIA BOYDII AND MONOSPORIUM APIOSPERMUM<sup>1</sup>

C. W. EMMONS

(WITH 9 FIGURES)

In 1922 Dr. C. L. Shear (5) published in this journal a description of a fungus isolated by Boyd and Crutchfield (1) from mycetoma of the foot. He named the fungus *Allescheria Boydii* and described an ascocarpic as well as byssoid and coremial conidial stages of development. This pathogenic fungus apparently has not been recognized since its original isolation although the name has been used in one instance (2) to designate a fungus similar except for the lack of ascocarps. *Monosporium apiospermum* Sacc. 1911, on the other hand, has been isolated from numerous cases of mycetoma. It bears a close resemblance to *A. Boydii*, but the similarity seems to have attracted little attention.

Recent observations in this laboratory demonstrate that *A. Boydii* is the ascocarpic form of *M. apiospermum*. Both fungi are etiologic agents of mycetoma of the foot, a mycosis characterized by swelling of the foot with sinus formation. The pus from a draining sinus contains small white granules composed of closely interwoven and radiating hyphae. Both fungi are gray byssoid molds, becoming olivaceous to brown with age and the formation of very numerous ovoid to egg-shaped or clavate conidia which are borne on simple or branching conidiophores. Coremia may or may not be formed. Several of the reported strains of *M. apiospermum* produced sterile sclerotia. In *A. Boydii* the corresponding structures are fertile ascocarps.

The fungus has a wide geographical distribution. The first strain of *M. apiospermum* known from Canada was isolated by Shaw and Macgregor (4) and described in detail by Dowding (3). It was received in this laboratory in December 1936 through

<sup>1</sup> From the Division of Infectious Diseases, National Institute of Health.

the courtesy of Dr. Dowding and has been carried in the culture collection since that time. During this interval important changes in its growth characteristics have occurred. Dowding observed that, unlike some isolates of the fungus, sclerotia were not produced by this strain. This was the case when the fungus was received from her, but in 1942 sclerotium-like bodies were observed in cultures. In subsequent transfers these structures appeared in increasing size and numbers and upon examination they were found to be fertile ascocarps. The ascocarps and ascospores resemble those described by Shear for *A. Boydii* except that the upper limit of size he reported has not been reached by any of the ascocarps measured. The conidia are like those reported by Shear for *A. Boydii* as well as like those characteristic of *M. apiospermum*. Coremia, as described by Shear, are rarely found and then only in rudimentary form (FIG. 1) in recent cultures of the Canadian strain although Dowding observed and described typical coremia at the time she studied it.

Many of the lower Ascomycetes, when carried in culture for years, lose the ability to produce ascocarps. This has occurred in the case of Dr. Shear's original strain of *A. Boydii* which, in this laboratory, has for many years produced only conidia of the *M. apiospermum* type. It appears probable that this ability, on the contrary, was acquired by the Canadian strain or that it reappeared. The possibility that the ascocarpic fungus was a contaminant seems remote since no other ascogenous strain of *Allescheria* has ever been carried in this laboratory. Three other strains of *M. apiospermum* carried in culture 7-10 years have not shown this method of sporulation.

In order to determine unequivocally whether the ascocarps observed in this old laboratory strain of *M. apiospermum* actually belonged to that fungus 150 single ascospores and 179 single conidia were isolated. This was accomplished by manipulations carried out for the most part within the field of view of a dissecting microscope under a magnification of 43 diameters. Small drops of sterile water were placed on the surface of cornmeal agar in a Petri dish. A single ascocarp was isolated, placed upon the agar surface, washed in a drop of water, then with a fine needle rolled across the agar surface from drop to drop of water, always

in the field of view of the microscope, until it was washed free of conidia. It was then removed to the agar surface in another Petri dish where it was crushed between two needles and the liberated ascospores were spread over the surface. This dish was incubated at 30° C. for 24 hours at which time most of the ascospores had germinated. Isolated germinated ascospores were picked out with a fine needle under the dissecting microscope and transferred to agar slants. Four ascocarps were used in making 150 ascospore isolations. Germinated ascospores were definitely differentiated from any conidia which might have been carried over by accident on the perithecium by their elliptical shape, pointed ends and manner of germination which were still apparent at the time the transfer was made. All isolations from ascospores were alike.

The isolations from conidia were made by spreading over the surface of cornmeal agar plates a suspension of conidia taken from a young culture in which ascocarps had not yet appeared. Some conidia germinated in eight hours and after twenty hours nearly all had developed a branching mycelium. Single germinated conidia were picked out under a dissecting microscope in the manner described above for ascospores. All conidial isolates were alike.

Cultures made from the two types of spores produced colonies identical in appearance and in the production of conidia and ascospores. Both spore forms belong, therefore, to one and the same fungus. Since single spores invariably produced colonies bearing ascocarps in abundance the fungus is homothallic.

Except for the presence of ascocarps this strain is typical of other strains of *M. apiospermum* which have been described in reports and which have been studied in this laboratory. On cornmeal agar the aerial hyphae are scanty, gray and decumbent. The colony becomes brownish with the formation of conidia and ascocarps which, on this medium, are borne in most cases below the agar surface (FIG. 2). On acid dextrose agar<sup>2</sup> growth is abundant, floccose, mouse-gray, and the conidia and ascocarps are borne in profusion on the aerial mycelium and on the agar surface.

<sup>2</sup> Modified Sabouraud's agar: dextrose 4%, Difco neo-peptone 1%, agar 2%, pH 5.6.



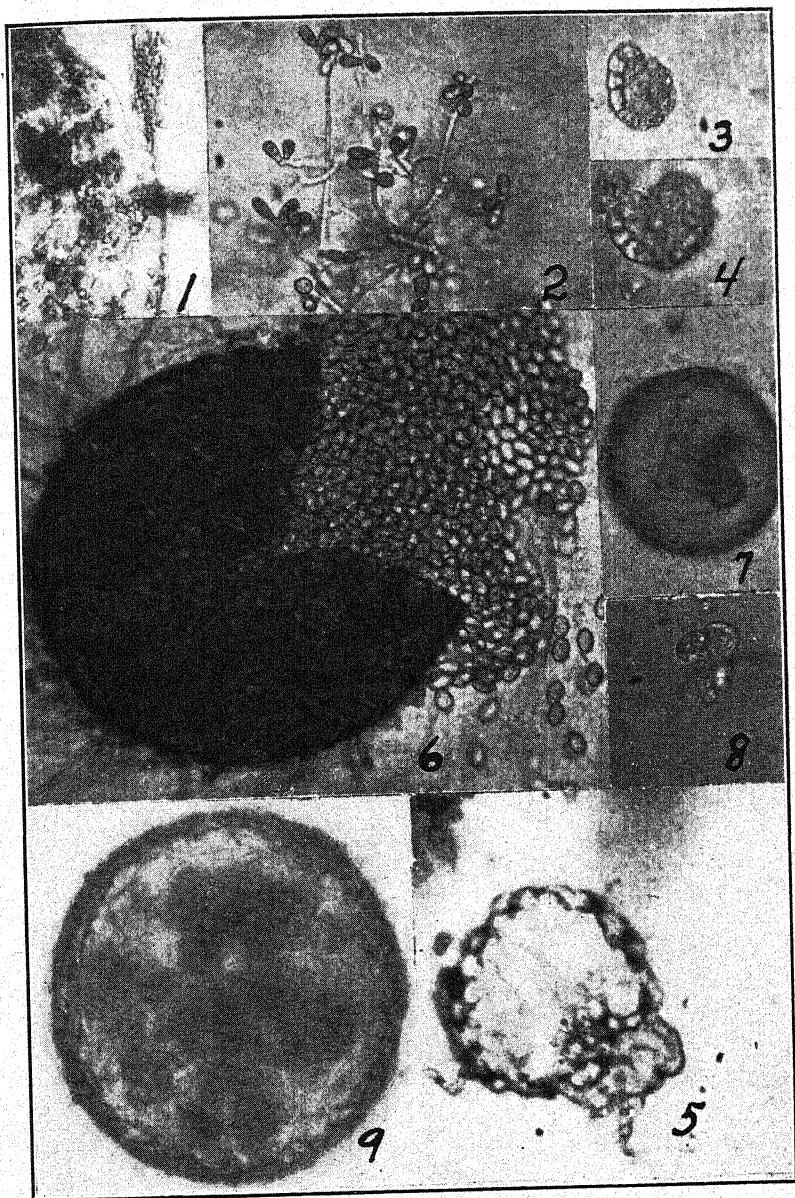


FIG. 1, Rudimentary coremium on dextrose agar; 2, conidia borne below the surface of the cornmeal agar; 3 and 4, young ascocarp with external ascogonial hypha persisting; 5, section of young ascocarp with ascogonial complex external to perithecial; 6, ripe ascocarp and ascospores; 7 and 9, young small ascocarps with asci visible through the perithecial; 8, two young asci from a crushed ascocarp.



The conidia (FIGS. 1, 2) are borne single (rarely in groups or serially on the same conidiophore) at the tips or laterally on simple or branched conidiophores which vary greatly in length. They are elliptical, egg-shaped or clavate, occasionally subglobose, and have a truncate base. The walls are somewhat thickened and brown. The conidia vary greatly in size ( $3.5-6 \times 5-10 \mu$ ), the measurements made in this laboratory being slightly less than those reported by Shear and Dowding.

The ascocarp is initiated by a coiled ascogonium. No differentiated antheridial cell could be definitely distinguished. The ascogonium remains visible for some time at one side of and external to a mass of small pseudoparenchymatous cells which produce the ascocarp (FIGS. 3, 4, 5). The first ascocarps to develop in a culture may reach a diameter of  $130 \mu$  (FIG. 6) which is smaller than the maximum size reported by Shear ( $200 \mu$ ). Ascocarps which develop later or under crowded conditions may mature when only  $50 \mu$  in diameter. The cleistocarpous perithecium is brown and is composed of a few cell layers so thin that asci and ascospores can be seen by transmitted light through the perithecium (FIGS. 7, 9). The asci are at first clavate (FIG. 8), becoming subglobose with the development of the eight ascospores (FIG. 7). They are so fragile that they are difficult to demonstrate in crushed mounts. The ascospores are elliptical with slightly pointed ends (FIG. 6). The walls are faintly brown. In the Canadian strain they measure  $4-4.5 \times 7-7.5 \mu$ .

The author gratefully acknowledges an opportunity to show this fungus to Dr. C. L. Shear and discuss it with him.

#### SUMMARY

A strain of *Monosporium apiospermum*, when isolated from mycetoma of the foot, yielded only conidia. After it had been carried in culture for six years it began to produce ascocarps which were identified as those of *Allescheria Boydii*. Production of both conidia and ascospores in cultures derived from single conidia and single ascospores proved that the two spore forms belong to one fungus, that *A. Boydii* is the ascocarpic stage of *M. apiospermum*, and that it is homothallic.

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NOTE

In the preparation of this article the writer overlooked an important paper (Jones, J. W. & Alden, H. S., Maduromycotic mycetoma (Madura foot). Report of a case occurring in an American negro. *Jour. Am. Med. Assoc.* 96: 256-260. 1931) in which an unusual strain of *Scedosporium apiospermum* (*A. Boydii* ?) was isolated. In the mycological section of the report, prepared in collaboration with Dr. F. D. Weidman, it was reported that sclerotia-like bodies found in cultures were perithecia containing spores. Probably because cultures of a suitable age were not examined asci were not observed. "It is evident that the fungus in question reproduces by means of spores not contained in asci or basidia and therefore must be classified as a Hyphomycete." *Allescheria* was not mentioned.

# ISOGAMOUS SEXUALITY IN A NEW STRAIN OF ALLOMYCES<sup>1</sup>

HAROLD E. TETER

(WITH 3 FIGURES)

## INTRODUCTION

Ever since the discovery by Kniep in 1929 of sexual reproduction and alternation of generations in the water mold, *Allomyces javanicus*, there has been considerable interest in the whole genus. Hatch (1933) found an identical cycle to be present in a fungus considered by him to be Butler's *A. arbusculus*. In both species gametophyte plants grew from swarmers released upon germination of the resistant sporangia of the sporophyte plant. Anisogametes released from the gametangia on the gametophyte fused in pairs to form zygotes which developed into sporophytes. Zoöspores derived from thin-walled sporangia on the sporophyte grew directly into new sporophytes.

Subsequent investigations have shown that there also exist strains of both of the aforementioned species which commonly pass through a short cycle involving the sporophyte only, the gametophyte being omitted altogether. In these cases the swarmers released from the resistant sporangia grow directly into new sporophytes. A third type of life history involving cyst formation was discovered by Emerson (1938). The nature of the life cycle in *A. moniliformis*, a species discovered by Coker and Braxton (1926), was found by Emerson in 1938 to be of this cyst forming type. Emerson did not describe this cycle in detail for *A. moniliformis*, merely stating that it was like that discovered by him in the species he later named *A. cystogenus*.<sup>2</sup>

<sup>1</sup> Contribution from the Department of Botany, University of Michigan, no. 735.

<sup>2</sup> Emerson first published his discovery of the *Cystogenes* type of cycle in 1938, but he did not erect the species *A. cystogenus* until 1941. In the interim, Indoh (1940) found in Japan a cyst forming strain which he considered to be the same as Emerson's material. He named it a new species calling it *A. neomoniliformis*. His name, therefore, takes priority over Emerson's if, as seems likely, the two fungi are found to be identical.

The most complete discussion of these three types of life cycles is to be found in Emerson's 1941 paper. Here, he calls them the *Euallomyces*, *Brachyallomyces*, and *Cystogenes* cycles, respectively.

The *Cystogenes* cycle is described by Emerson as consisting of a type of diplanetism within a short cycle. According to him the swarmers which leave the resistant sporangium are large, biflagellate, and quickly encyst. From these cysts uniflagellate swarmers, typically four in number, are said to emerge. These "secondary R. S. swarmers" are then reported to develop directly into normal sporophyte plants.

McCranie (1942), studying the same Burma 1-B strain with which Emerson did most of his work, contradicted Emerson on two important points. Firstly, he claimed a complete absence of flagella in the primary R. S. swarmers. Secondly, he claimed to have observed the secondary swarmers fusing in pairs to form biflagellate zygotes from which sporophyte plants developed. McCranie also emphasized the irregularity in size of the cysts and of the variable number of swarmers emerging from them.

In an attempt to resolve these points of variance regarding *A. cystogenus* and further to study this very interesting type of cycle, the present writer has been conducting observations on strains of two cyst forming species. Although this study is not complete, it is felt that the results obtained thus far are of sufficient significance to warrant this preliminary report.

#### MATERIALS AND METHODS

The two fungi which are the objects of the present investigation are *Allomyces cystogenus* Emerson and a new strain from Trinidad which resembles, in many respects, *A. moniliiformis*. The material of *A. cystogenus* was from a sub-culture of the Burma 1-B strain first isolated by Emerson and used by him for most of his work on the cyst forming cycle (1941: 84). It was sent by him to Dr. F. K. Sparrow, who gave it both to McCranie and to the author. The strain is remarkable for the ease with which its resistant sporangia can be induced to germinate. The Trinidad fungus was isolated by Dr. F. K. Sparrow from dry soil brought to him by Dr. W. R. Taylor from a rice paddy near the asphalt pits of Trinidad, B. W. I.

Observations were made on material mounted in hanging drop cultures. In the cyst-forming species of *Allomyces* the resistant sporangia are strongly deciduous. It was a simple matter, therefore, to draw into a capillary tube some of these bodies which had fallen to the bottom of old water cultures and to transfer them to cover slips. These slips were then inverted onto glass rings to form hanging drop cells. The Burma 1-B strain needed no further inducement to germinate, and the whole process was watched many times as it occurred in these cells. This method differed somewhat from Emerson's, who, apparently, used resistant sporangia taken from pure agar cultures. It differed from McCranie's with respect to the use of hanging drops. McCranie placed his material directly on microscope slides with supported cover slips over the top.

With the Trinidad strain, germination of resistant sporangia was induced by placing them in fresh water in a watch glass and leaving them at 4° C. for a day or two. The watch glass was then brought back to room temperature and some of the resistant sporangia removed to cover slips, where they were dried down for a day or more before wetting and mounting in hanging drops. Even then, germination was uncertain, so that some phases of the cycle were seen only once or twice.

All the molds were grown in boiled hemp seed in sterile water. The cultures were unifungal and reasonably clean. No attempt was made, however, to rid them of bacteria.

#### OBSERVATIONS ON AN *ALLOMYCES* FROM TRINIDAD

As previously stated, the resistant sporangia of this species are not easily induced to germinate, and, although all stages in the life history were observed, some of them were seen only once or twice. There was no indication, however, that the observed behavior was anything but typical.

The most remarkable feature of this strain was that so far as could be determined all of its swarmers were completely devoid of flagella. They moved about in a weakly amoeboid fashion, never getting far from their place of origin. In asexual reproduction the thin-walled zoosporangia developed escape papillae which deliquesced to form pores through which the amoeboid

zoöspores emerged. These spores were comparable in size ( $8 \times 11 \mu$ ) and general appearance to other swarmers of the genus, but no flagella could be seen either in living examples or in ones which had been killed and stained. Their movements were far less effectual than the amoeboid locomotion often resorted to by the flagellate swarmers of other species. Although the swarm period of these zoöspores was probably of normal duration they usually failed to progress more than three or four hundred microns before encysting and sending out rhizoids.

Repeated emergence of encysted zoöspores seemed to be of normal and frequent occurrence. It was also found that even

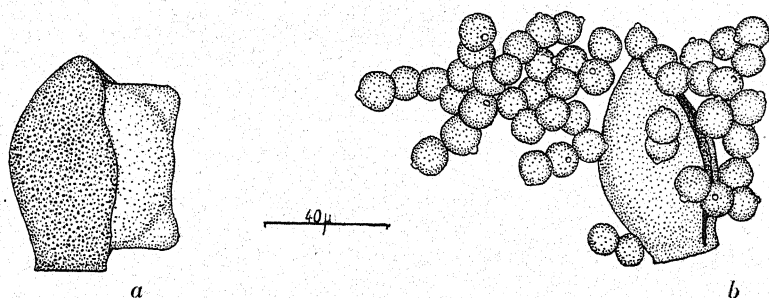


FIG. 1. The Trinidad isolate of *Allomyces*. a. The germinating resistant sporangium. The contents have swelled out and formed two escape papilla. b. Cysts formed by the amoeboid "primary R. S. swarmers."

after a fairly extensive rhizoidal system had developed on the encysted zoöspore, a somewhat undersized swarmer might emerge from the cyst and go through another period of amoeboid swarming before again encysting. After emergence the empty cyst wall, with or without rhizoids, was always left behind.

This phenomenon of repeated emergence, although common among certain other water molds, is apparently of less frequent occurrence in *Allomyces*. The only previous record of such behavior in encysted and ungerminated zoöspores, known to the writer, is to be found in the plate accompanying Coker and Braxton's paper (1926) describing *A. moniliformis*. This figure shows what is labeled as a spore "escaping from cyst." The text, however, makes no mention of this and describes the zoöspores as monoplanetic. Emerson (1941) notes this as a discrepancy between the text and figure and concludes that what Coker and

Braxton actually saw was cyst formation by planonts derived from resistant sporangia. In view of the frequency with which repeated emergence was observed in the Trinidad strain it would seem that the Coker and Braxton figure does, in fact, refer to zoöspores. Likewise, the designation of "monoplanetic" is correct, for repeated emergence is not true diplanetism in the commonly accepted sense of the term. The Saprolegniaceae, for instance, are considered truly diplanetic because in some genera the swarmers regularly form, as an essential part of the life history, cysts which give rise in turn to secondary swarmers different in their morphology from the primary ones. In cases of repeated emergence, on the other hand, a spore which would

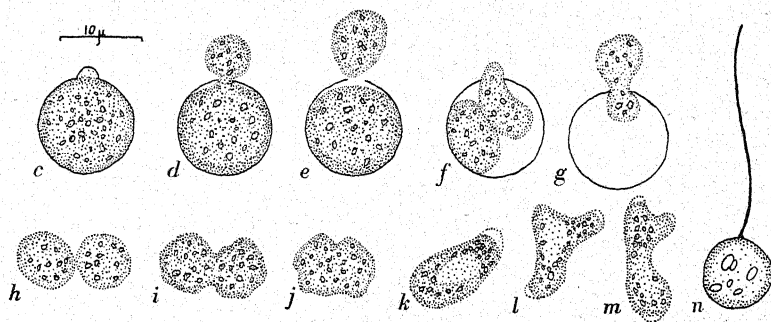


FIG. 2. Trinidad isolate of *Allomyces*. *c*. A cyst formed by a "primary R. S. swarmer." *d*, *e*. First amoeboid gamete escaping from cyst. *f*. Third gamete starting to escape. *g*. Fourth gamete emerging. Empty cyst left behind. *h*, *i*, *j*. Stages in the fusion of two gametes. *k*. Typical aspect of zygote. *l*, *m*. Irregular shapes sometimes assumed by zygote in its amoeboid movement. *n*. Encysted zygote putting out a germ tube.

normally encyst and develop directly into a new plant fails to do so, due to special conditions such as starvation. Instead, the protoplasm organizes itself once more as a swarmer (or swarmers in some species) and emerges to seek further for a suitable substrate. A good example of such repeated emergence is to be found in Sparrow's paper (1931) on *Pythium adhaerens*. In the Trinidad strain, the term "repeated emergence" can be used only in referring to those cases where the new swarmer emerges before any rhizoids have formed. The functioning of tiny germlings as zoösporangia has been reported by Emerson (1931) for all species of *Allomyces*.

Although the amoeboid, non-flagellated nature of the zoöspores in the Trinidad fungus gave every appearance of being a normal manifestation, it seemed possible that, as has been found to be the case in other water fungi, environmental factors might be responsible. To check this possibility two series of cultures were started, one of a North Carolina strain of *A. moniliformis*<sup>3</sup> and one of the Trinidad strain. Sterile water from the same flask was poured into identical dishes. The same number of boiled hemp seeds was introduced into each, and each was inoculated by placing a tuft of fungous filaments near the seeds. The two series of cultures were kept side by side to eliminate the possibility of temperature differentials. Growth in both cultures seemed normal and vigorous. After eleven days, filaments were removed from both cultures and placed in hanging drops. The thin-walled sporangia of the North Carolina material gave rise to normal, flagellated zoöspores. Those of the Trinidad strain produced only amoeboid types.

The sequence of events in the germination of the resistant sporangium of the Trinidad fungus was followed. The first sign of germination is the appearance of a longitudinal split along one side of the outer pitted sporangial wall. The sporangial contents, covered by the thin, inner wall, swell out through this opening to form a structure about double the original volume. The outer wall remains, clasping this enlarged structure on one side (FIG. 1, *a*). Soon escape papillae form which, upon maturity of the structure, deliquesce simultaneously. Through the openings thus produced the fully formed planonts escape rapidly. These planonts are what Emerson calls the "primary R. S. zoöspores." They are without flagella and average about 11.5  $\mu$  in diameter when spherical. When in motion they are ellipsoidal. Their movement is strongly amoeboid. They are, in fact, capable of more effective movement than any of the other types of swimmers observed in this strain. Their activity is short lived, however, for they soon round up and encyst (FIG. 1, *b*). Oftentimes the first ones to emerge have already encysted before

<sup>3</sup> This is the North Carolina strain 3 of Emerson (1941). It was given to the writer by Dr. F. K. Sparrow, who obtained it from Dr. J. N. Couch.



the last ones escape. The cysts may either remain quiescent for several hours, or they may germinate within an hour.

These cysts are, in reality, miniature gametangia. Each forms a single exit papilla (FIG. 2, *c*) which deliquesces to allow the escape of four isogamous amoeboid gametes (FIG. 2, *d-g*), each typically about  $9.5\ \mu \times 6.5\ \mu$ . They emerge from the cyst singly and crawl about with an extremely weak amoeboid motion in the immediate vicinity of the exit pore. It may take several

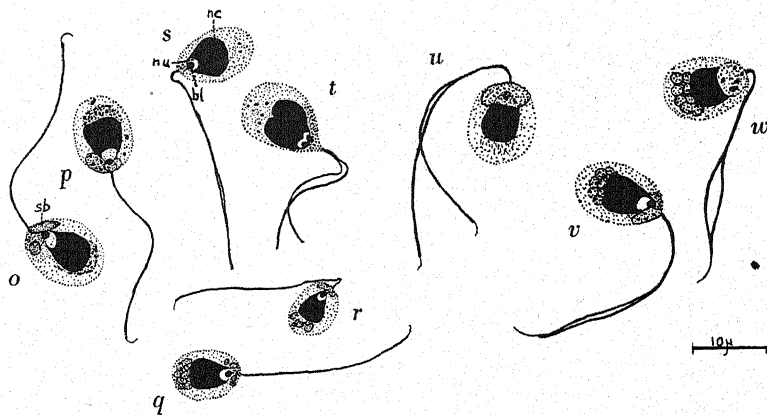


FIG. 3. Stained planonts of *Allomyces cystogenus*. *o, p*. Zoospores stained by the wet gentian violet method. *sb*. Structure possibly corresponding to "side bodies" found by Couch and Whiffen in *Blastocladiella*. *q, r*. Gametes stained by the wet gentian method. "*q*" is of normal size for gametes. *s, t*. Zygotes stained by the dry gentian violet technique. In "*t*" the nuclei have not yet completely fused. *nc*. Nuclear cap. *nu*. Nucleus. *bl*. Blepharoplast. *u*. Zygote stained by wet safranin. *v, w*. Zygotes stained by the wet gentian violet method.

minutes for a gamete to progress a single length forward. All of the forty or more cysts from a single resistant sporangium germinate simultaneously. As a result, the numerous gametes thus released soon become so thoroughly intermingled that it is impossible to trace with certainty the place of origin of any particular gamete. It cannot be definitely said, therefore, whether or not gametes from a given cyst are compatible. Preliminary observations seem to indicate that they are not.

As the gametes move weakly about they come together in pairs and fuse (FIG. 2, *h-j*), a process which may be accomplished

smoothly and quickly or be a more protracted one involving much preliminary contracting and jerking. Because of the limited powers of locomotion of the gametes it is often a matter of a few hours before all have found mates. The zygotes (FIG. 2, *k-m*) are similar in size, appearance, and behavior to the ordinary zoöspores formed in the thin-walled zoösporangia. They undergo a period of weak amoeboid locomotion after which they come to rest, encyst, and put out a germ tube (FIG. 2, *n*). In this manner a new generation is established. One or two cases of repeated emergence of the zygote were observed.

The life cycle of the Trinidad strain of *Allomyces* can be summarized as follows: The mature plant produces two kinds of reproductive structures, (A) thin-walled zoösporangia, and (B) thick-walled resistant sporangia.

A. The zoösporangia give rise to numerous amoeboid zoöspores, each of which may grow into a new sporophyte plant, with or without passing through repeated emergence first.

B. The resistant sporangia can survive drying and serves, therefore, to carry the species through periods of adverse environmental conditions.

1. When resistant sporangia finally germinate, amoeboid "primary R. S. swarmers" are produced.

2. These swarmers quickly encyst, the cyst constituting a much reduced gametophyte.

3. Each cyst discharges four equal-sized, non-flagellated gametes.

4. The gametes fuse in pairs to form zygotes.

5. After a swarm period the zygotes may encyst and go through repeated emergence or more commonly, germinate directly into new sporophyte plants.

One further feature of interest was noted. It was repeatedly observed that mycelia of the Trinidad isolate exhibited a capacity for conserving protoplasm in severed hyphae. This has frequently been observed not only in this species but in the others of the genus as well. It is probable that many workers must have seen this phenomenon but apparently none has recorded it. When filaments of the fungus are removed from a hemp seed and placed in a hanging drop they have, of course, been cut off from

their food supply. Furthermore, the coenocytic hyphae have been severed near the base and a certain amount of protoplasm runs through the broken end. This "bleeding" is not as extensive as might be expected, however, for the plant is able to retain a surprisingly large proportion of its protoplasm. The pseudosepta are probably an important factor in checking the escape of the hyphal contents, for one often sees concentrations of protoplasmic material crowded on one side of a septum. At all events, the plant is left with much of its protoplasm and included food reserves (mainly fat globules) still intact. In some instances its reaction to this injury may be the production of numerous new hyphae which seek out possible sources of nutrition. Usually, however, the tendency of such injured hyphae is to conserve the now isolated protoplasm by drawing it together into several chumps within the filament, each of which subsequently develops into a zoösporangium. These sporangia may be terminal or in chains, as is typical of the species, or they may be intercalary and isolated from one another. This ability of protoplasmic fragments under certain conditions to form zoösporangia is of obvious survival value to the fungus.

Definite identification of the Trinidad fungus with an already described species has been avoided. In general morphology it closely resembles *Allomyces moniliformis* Coker & Braxton (1926). Its pointed resistant sporangia, its zoösporangia of variable length, and its *Cystogenes* type of life history would place this fungus in the Coker & Braxton species. The amoeboid planonts of the Trinidad strain, however, set it apart from this and all other species of *Allomyces*. Nevertheless, the writer hesitates to erect a new species on this single character until further experimentation and observation establish beyond question that under no conditions are flagella ever formed. Should it be found possible to induce the formation of flagella, the strain could be considered to be no more than a variety of *A. moniliformis*.

#### CONFIRMATION OF ISOGAMY IN ALLOMYCES CYSTOGENUS

The life cycle of *Allomyces cystogenus* (Emerson's Burma 1-B strain) proved to be in every way similar to that of the Trinidad fungus save for the fact that the swarmers were flagellate. As

already described by both Emerson (1938, 1941) and McCranie (1942), the outer wall of the resistant sporangium splits, usually across the rounded end and down each side. The protoplasmic contents within the elastic inner wall then swell out through this split and soon form escape papillae. Some cases were observed in which the contents slipped completely free of the outer wall of the resistant sporangium and assumed a spherical form out in the water. The "primary R. S. swimmers" are released upon the deliquescence of the papillae.

The planonts which emerge from the resistant sporangia are typically of rather uniform size, averaging, when spherical,  $11.5 \mu$  in diameter. At times, especially when there was reason to suspect that the oxygen content of the water was low, the planonts were very unequal in size, ranging from seven to over thirty microns in diameter. Since McCranie observed his material under a supported cover slip, where the water would probably be poorly supplied with oxygen, it is not surprising that he considered variability in size to be typical of these swimmers. It is likewise understandable that Emerson should have found uniformity to be the rule, for he transferred his material from pure agar cultures directly to hanging drops where an abundance of oxygen would be available. The presence or absence of flagella on these swimmers seems, likewise, to be conditioned by culture methods. Emerson found them uniformly biflagellate whereas McCranie asserted that they were amoeboid and lacked flagella completely. The writer, with methods which might be considered to be intermediate between the others so far as aeration was concerned, found the amoeboid, non-flagellate condition common. In many cases, however, planonts were observed under these conditions which bore one to four or more flagella. The flagellar action of these planonts was never more than an uncoordinated thrashing about. Movement of any sort was of very limited duration. Frequently the first group of spores to emerge came out as a shapeless mass which quickly rounded up into numerous discrete bodies. These often encysted at once without further movement. The remaining swimmers, with or without flagella, emerged successively by amoeboid movement and soon they, too, became encysted. Often the first ones to escape encysted so near

the opening of the sporangium that they trapped those remaining inside. These entrapped swimmers could frequently be seen crawling about for a considerable length of time before they, too, rounded up and encysted.

The cysts thus formed function as small gametangia, just as they do in the Trinidad fungus. Each develops a single escape papilla which deliquesces to allow the uniflagellate gametes to emerge. These bodies average about  $9.5 \times 6.5 \mu$ . Although they are active and capable swimmers, they seldom move far, tending, rather, to stay in the immediate vicinity of the cysts. The greater number of these cysts measure  $11.5 \mu$  in diameter. Each gives rise uniformly to four gametes. Other cysts, either larger or smaller than these typical ones, produce numbers of gametes proportionate to their sizes. Since the volumes of spheres vary directly as the cubes of their radii, it is possible to predict with accuracy how many gametes can be expected from a cyst of a particular size. As a result of the fact that all the cysts from one resistant sporangium germinate within a few minutes of each other, there is produced a large mass of gametes which swarm about and crawl over one another in a most confusing manner. It is frequently difficult, therefore, to follow the sequence of their activities.

By carefully following the movements of individual gametes it is possible to observe actual fusion. Two gametes will come together, glide about amoeboidly over one another, and finally merge. The flagella come to lie side by side and act as one, so that the living zygote appears to be uniflagellate. These zygotes look and act like typical *Allomyces* zoöspores. After a swarm period they come to rest, lose their flagella, encyst, and send out germ tubes. Many times several gametes simultaneously come together and crawl over one another, making it difficult to see which ones finally fuse. Often two gametes which appear to be fusing will suddenly jerk apart as though they were incompatible. The time taken for actual fusion varies, seemingly being dependent upon the relative positions of the gametes when they first make contact. If they lie side by side with flagella parallel, their bodies flow together effortlessly, and the zygote swims away within a minute or less. When the gametes are not so well

aligned at the outset, several minutes of violent threshing about may ensue before the two flagella come to lie parallel and function as one.

In order to study more carefully the various planonts of this fungus, gametes, zygotes, and ordinary zoöspores were killed and stained. The swarmers, in drops of water, were killed by exposure to osmic acid fumes. Some were dried down in aqueous gentian violet, destained in clove oil and orange G, and mounted in balsam (Cotner's method). Others were observed at once after staining in weak aqueous solutions of gentian violet or safranin (Couch and Whiffen 1942). The first method yields inferior results in that it leads to shrinking and distortion. Furthermore it fails to show as much cellular detail as when Couch's method is followed. The cell contents as revealed by Cotner's method consist of a large, deep staining, nuclear cap at the base of which is the lighter nucleus (FIG. 3, *s*, *t*). The latter contains at its base a dark staining object, probably a blepharoplast, which is intimately connected with the flagellum. Couch's method (FIG. 3, *o-r*, *u-w*) shows, in addition to these parts, the food globules so prominent in living material. These stain moderately with the gentian violet but only slightly with safranin. This method also reveals about the base of the cell an irregular mass of material which may well correspond to the "side body" found by Couch and Whiffen (1942) in swarmers of *Blastocladiella* (the "Zeitenkörper" of Stüben, 1939). In *A. cystogenus* this structure never extends so far up the side of the cell as was found by Couch and Whiffen to be the case in *Blastocladiella*. Indeed, it seldom extended much above the top of the nucleus (the flagellated end is here considered the basal end, or "bottom" of the cell). For this reason the identification of this structure in *A. cystogenus* with the "Zeitenkörper" of Stüben and "side body" of Couch and Whiffen must remain tentative for the time being. The zygotes, in all cases, showed two flagella, although these, even in stained mounts, were often so closely appressed laterally as to appear as one. Evidently the nuclear caps, nuclei, and blepharoplasts of the gametes all fused, so that only one of each of these structures was to be found in the zygote. Cases were found where the staining technique had caught the fusion

in progress (FIG. 3, *t*). In size, appearance, and behavior, there is nothing to distinguish the zygote from the zoospore save, of course, its double flagellum.

#### DISCUSSION

It becomes apparent, as Emerson has pointed out, that the life cycles here described represent a shortening of the *Euallomyces* type of cycle. The cyst probably represents a much reduced gametophyte generation, for like a gametophyte, it is derived from a "R. S. swarmer" and gives rise to gametes. We can consider, therefore, that in the *Cystogenes* type of cycle the gametophyte is reduced to a single gametangium, the cyst. It might be contended that the *Brachyallomyces* cycle represents a still further simplification in which the gametophyte is suppressed altogether. The *Cystogenes* cycle would, then, be the transitional type. That such is not the case is indicated by the readiness with which some strains of the *Brachyallomyces* type revert, under proper conditions, to a long cycle (see Emerson, 1941). Furthermore, the strains of the *Brachyallomyces* and *Euallomyces* types are indistinguishable morphologically, whereas the *Cystogenes* types can, as Emerson has shown, be recognized not only by their life histories but by certain structural features as well. Among these are coarsely pitted resistant sporangia and, in *A. moniliformis*, pointed ends to the resistant sporangia.

A most remarkable parallelism in behavior is to be found between *A. cystogenus* and *Blastocladiella cystogena* as reported by Couch and Whiffen (1942). The cyst formation, gametic fusion, and zygote behavior (two flagella lying parallel and functioning as one) are so nearly identical that a description for one could easily serve for the other.

In one respect the behavior in *A. cystogenus* differs from that in *Blastocladiella cystogena*. Couch states that the planonts which emerge from the resistant sporangium in *B. cystogena* are uniflagellate. In *A. cystogenus*, on the other hand, the number of flagella may vary from none to several. Emerson, as we have seen, considers two flagella to be the normal number under optimum conditions. McCranie denied the existence of any flagella. The author is inclined to accept Emerson's conclusions

on this point, for he did not exactly duplicate Emerson's methods (nor are they, in all probability, ever duplicated in nature). It seems likely that the number of these flagella present on the "R. S. swarmer" may represent the number of nuclei in its cytoplasm. This would suggest the possibility that the first meiotic division of gametogenesis takes place in the "R. S. swarmer" prior to its emergence from the resistant sporangium and that the second division takes place in the cyst. Cytological evidence will be needed to prove or disprove this hypothesis.

In connection with the observations on the Trinidad strain herein described it is of interest to note how few records exist of nonflagellate spores among the uniflagellate aquatic Phycomycetes. *Amoebochytrium rhizidioides*, seen once by Zopf (1884), has nonflagellate spores capable of amoeboid motion. *Sporophlyctis rostrata* Serbinow (1907) and *Sporophlyctidium africanum* Sparrow (1938) have spores without flagella and apparently incapable of any sort of movement (aplanospores). Thus, of the many species of the uniflagellate series of aquatic Phycomycetes now known, only four produce aflagellate spores, and, of these, only two exhibit amoeboid movement.

Since this study has added still others to the various types of planonts already known for the genus *Allomyces* the following tabulation is presented as a convenient summary. It will be noted that twelve distinct types of swarming bodies are found among the various species. The number found in any one strain ranges from two to five. It will be further noted that no one type is common to all strains. While pointing out the differences between the various planonts it should be borne in mind that all types are very similar in internal structure.

#### TYPES OF PLANONTS FOUND IN THE GENUS ALLOMYCES

*Euallomyces* Type—*A. arbusculus*, *A. javanicus*:

1. Zoöspore (uniflagellate,  $8 \times 11 \mu$ ) from thin-walled zoösporangium on the sporophyte. Germinates to form another sporophyte.
2. Uniflagellate spore from the resistant sporangium of the sporophyte. Germinates to form a gametophyte.



3. Female gamete (uniflagellate) from female gametangium on the gametophyte. May sometimes develop parthenogenetically into a gametophyte.

4. Male gamete (uniflagellate; half as big as 1, 2, and 3 above) from male gametangium of the gametophyte. Fuses with female gamete in the water.

5. Zygote (biflagellate). Germinates to form a sporophyte.

*Brachyallomyces* Type—*A. anomalus*:

1. Zoöspore (same as 1 above).

2. Spore from a resistant sporangium. Like 2 above except that it grows into a sporophyte.

*Cystogenes* Type

A. *A. cystogenus*, *A. moniliformis*:

1. Uniflagellate zoöspore. Like 1 in *Euellomyces*.

2. "Primary R. S. spore." Typically biflagellate (?). Forms cyst 11.5  $\mu$  in diameter.

3. Uniflagellate isogametes (9.5  $\mu$ ). From cyst (usually four in a cyst).

4. Biflagellate zygote. Equal in size to a zoöspore. Germinates to form a sporophyte.

B. The Trinidad Isolate:

1. Amoeboid, aflagellate zoöspore.

2. Amoeboid, aflagellate "primary R. S. swarmer." Forms cyst which gives rise to four gametes.

3. Amoeboid, aflagellate isogametes. Fuse to form zygotes.

4. Amoeboid, aflagellate zygote. Germinates to form a sporophyte.

SUMMARY

1. Since Emerson's discovery of a cyst-forming cycle in *Allomyces cystogenus* (*A. neomoniliformis*), McCranie claims to have found sexual fusion to be present between the isogamous "secondary R. S. swarmers." This is in contradiction to Emerson. To resolve the argument two species of the cyst-forming type were studied, one a subculture of Emerson's *A. cystogenus* and the other a new strain from Trinidad resembling *A. moniliformis*.

2. In the Trinidad strain "primary R. S. swarmers," gametes, zygotes, and zoöspores, were found to be amoeboid and devoid of flagella.

3. The fusion of isogamous gametes was observed many times in both species and appears to be the rule. McCranie's statement that no flagella ever occur on the primary swarmers could not be substantiated, although the "typical" number of these flagella remains in some doubt.

4. The general morphology of the swarmers was studied:

5. The almost perfect parallelism between the life cycles of *Allomyces cystogenus* and *Blastocladiella cystogena* (Couch and Whiffen, 1942) is pointed out.

#### ACKNOWLEDGMENTS

The writer is indebted to Dr. Ralph Emerson for his kindness in permitting the use of the Burma 1-B strain. He is especially grateful to Dr. F. K. Sparrow for supplying the Trinidad strain and for his numerous helpful suggestions in the preparation of this paper.

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## SPERMATIAL FORMATION IN GYMNO- SPORANGIUM CLAVIPES

LINDSAY S. OLIVE

(WITH 2 FIGURES)

Since Blackman (1904) presented what appeared to be a rather complete account of spermatial formation in *Gymnosporangium clavariaeforme* Rees, little has been added to his description. The present writer has chosen for investigation *Gymnosporangium clavipes* Cooke & Peck, a species which has exceptionally large spermagonia (FIG. 1) and spermatial hyphae. This rust occurs abundantly in our area, with its spermagonia and aecia on *Amelanchier*, *Choenomeles* and *Crataegus*, and its telia on *Juniperus virginiana*.

Diseased fruits of *Amelanchier* showing fresh spermagonia over their surfaces were collected and placed in formalin-acetic-alcohol solution. Various stains were used, including iron-alum haematoxylin, safranin and gentian violet, and Flemming's triple stain. Practically all of the drawings were made from material treated with the triple stain, which seemed the most effective.

Upon careful examination of the spermatial hyphae, it was discovered that there is an open collar at the tip of each hypha, and that the spermatia are budded off through this opening (FIG. 2: 1-14). The young bud first pushes its way up through the opening of the collar (FIG. 2: 1-3) and enlarges just above the rim of the collar (FIG. 2: 4-8). In the meantime, nuclear division occurs in the spermatial hypha and a nucleus passes up into the developing spermatium, as Blackman (1904) has already described in detail. The mature spermatium is cut off by constriction at its base (FIG. 2: 9, 12, 13), not by the formation of a cross wall between it and the tip of the hypha, as Blackman described for *G. clavariaeforme*.

The next spermatial bud appears very soon after the preceding one is constricted off and displaces the latter from the mouth of the collar (FIG. 2: 10, 11). Occasionally the spermatia may be

found still clinging together in chains of two or three (FIG. 2: 12, 13). Figure 14 shows the collar at the tip of a spermatial hypha, from which the spermatia have been dislodged. The diameter of the collar's opening is variable, as can be seen in the figures. Moreover, the collar wall is generally thickened and takes the orange gold stain quite well. The thickness of this wall is variable, as the drawings indicate. Blackman (1904), in

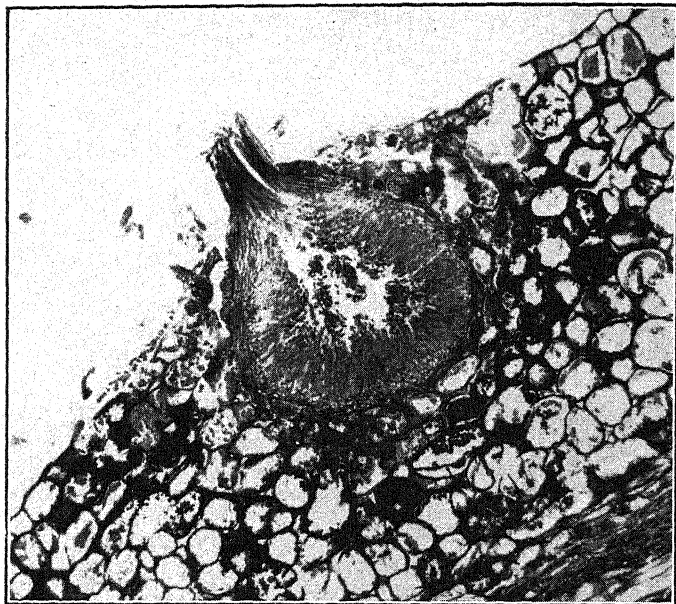


FIG. 1. Section through spermatium of *Gymnosporangium clavipes* on fruit of *Amelanchier*,  $\times 100$ .

describing the spermatial hypha in *G. clavariaeforme*, stated: "It is furnished at the free end with a curious ring of thickening, which is easily rendered visible by the fact that it takes Congo-red with more avidity than the rest of the cell-wall." He illustrated the ring-like thickenings in his drawings of the spermatial hyphae, but evidently did not observe that they were actually open collars through which the spermatia are budded.

It appears from the foregoing observations that the spermatium is primarily a uninucleate naked cell which originates as a bud from the protoplasm at the base of the collar. On the other hand, Craigie (1933), Allen (1933) and others have shown that

when the spermatium fuses with a receptive hypha, an empty cell wall is left outside the hypha after its contents have emptied into the latter. However, most or all of this cell wall appears to be laid down after the spermatium has been discharged from the

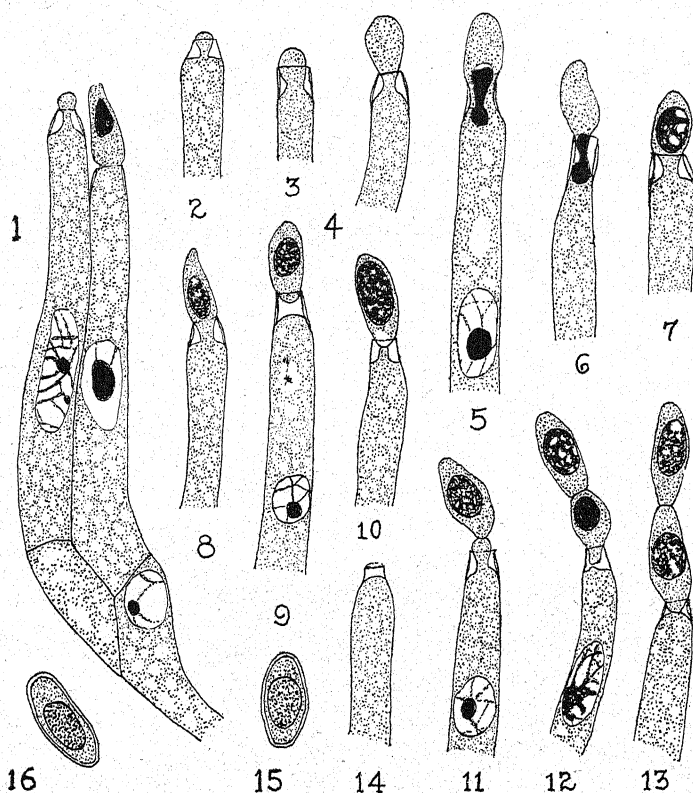


FIG. 2. *Gymnosporangium clavipes*. 1-14, steps in the production of spermatia from the spermatial hyphae; 15, 16, spermatia with cell walls, found on surface of *Amelanchier* fruit,  $\times 1825$ .

hypha which produces it. Indeed, there does not appear to be a cell wall around any of the spermatia in the cavity of the spermatogonium, where they are surrounded by a liquid medium of nectar. On the other hand, a thin cell wall may be seen around some of the spermatia among the paraphyses, while there is a very conspicuous cell wall around those spermatia which have been discharged over the surface of the *Amelanchier* fruit (FIG. 2:

15, 16). Thus the formation of the cell wall around the spermatium appears to be a secondary phenomenon, associated with the transfer of the spermatium from a liquid medium to the air.

It is interesting to note that the method of spermatial formation in *G. clavipes* is like that found in various Ascomycetes by a number of investigators. Essentially the same method has been observed by Thaxter (1896) in the antheridia of the Laboulbeniales and by Whetzel (1937, 1942) in the spermadochia of *Septotinia* and *Martinia*, respectively. Brierley (1918) found a strikingly similar method in the formation of microconidia in *Botrytis cinerea*, while Dodge (1932) observed a slight modification of this method in the production of microconidia in *Neurospora sitophila*. Moreover, Dodge discovered that cultures of the fungus could be spermatized with these microconidia.

The same phenomenon found in the spermagonium of *Gymnosporangium clavipes* will doubtlessly also be found, upon closer observation, to be common for the rusts in general. Moreover, if a similar investigation be carried out on the spermagonia, or pycnidia, of the Ascomycetes, the discovery of a similar method there would furnish us with an even better criterion for determining phylogenetic relationships in methods of spermatial formation in the rusts and Ascomycetes.

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## BOXWOOD BLIGHTS AND HYPONECTRIA BUXI

B. O. DODGE

(WITH 2 FIGURES)

Those who are familiar with diseases of boxwood will probably agree that the most damage is due to the leaf blight or die-back disease caused by the fungus usually referred to as *Volutella Buxi*. The perfect or ascocarpic stage of this fungus is said by Pape and others of Germany, and by several American authors, to be *Nectria Rousseliana*. Leaves turn straw-yellow, or light tan colored, and smaller twigs die-back for some distance. Winter injury also results in a yellowing and dying of the top leaves, so it is not always easy to distinguish one trouble from the other. White<sup>1</sup> has described a canker disease of box due to the same fungus. He says that the first symptoms of canker are delayed new growth in the spring and the later yellowing of leaves which are then often attacked by *Macrophoma Candollei*, as well as by other fungi. The bark of the cankered portion of the stem becomes loosened and peels off readily, showing dead discolored wood. He believes that infection takes place when the fungus descends from infected side branches or where quantities of dead leaves bearing the *Volutella* fungus collect in crotches.

Not infrequently one finds pale-pink or coral colored sporodochia of *Volutella*, or a whitish hyphomycetous growth of *Verticillium* on the dying branches and leaves. This has been assumed to serve to distinguish the blight from winter injury. If no spore pustules are evident it is the custom to place the suspected material in a damp chamber or under a bell jar for a few days. Under these moist conditions the fungus will grow out if present. During the past we have had occasion to report on dozens of cases of this box blight. Some years ago in collaboration with Marjorie E. Swift<sup>2</sup> we made rather extensive

<sup>1</sup> N. J. Agric. Exp. Sta. Circ. 226. 1931.

<sup>2</sup> Dodge, B. O. and Marjorie E. Swift. Notes on boxwood troubles. Jour. N. Y. Bot. Garden 31: 191-198. 1930.



culture studies of the fungi which develop on the dead and dying leaves and twigs. We stated that cultures derived from the *Verticillium* spores develop not only *Verticillium* but also sporodochia of *Volutella Buxi*. Cultures taken from the *Volutella* spores in nature develop both types of spore-producing structures, so that it appeared that *Verticillium Buxi* and *Volutella Buxi* are simply different types of fructification of the same fungus. The writer now, however, believes that there are some grounds for questioning this statement. We have never seen the perfect or ascocarpic stage of *Nectriella Rousseliana* on the blighted leaves in nature, but have always assumed that if one looked in the right place at the right time they must be found.

Late in 1943 Mr. Aymar Embury II of East Hampton, Long Island, brought in some branches of boxwood which showed a number of dead and dying leaves and some shrivelling of the bark. Many of the leaves were marked on the under side by a reddish rust-brown flecking (FIG. 1). Such leaves always had on the lower side many small sunken spots or pits (FIG. 2). On a former occasion, a similar pitting of one leaf of a specimen brought to the laboratory was noticed, but in that case the pitting was associated with small blackish flecks so that superficially the leaf looked as though it had been infected by some spot disease fungus. The material brought by Mr. Embury, however, proved that the pittings represent collapsed subepidermal perithecia. The asci were of the sort commonly developed by species of *Hyponectria*, a genus of Nectriaceae. The ascospores which were being matured were hyaline, oblong and one-celled. Some of the leaves showed a white *Verticillium* overgrowth on the under side and also sporodochia of a *Volutella*. When leaves were soaked for a few hours in water or were placed in a damp chamber over night, one could see by transmitted light that the pits had been filled out with the swollen contents of ascocarps. Some of the perithecia had definite ostioles. It was difficult to separate the reddish brown perithecial walls from the leaf tissues; the lower epidermis also seemed to be more or less involved. After two or three days in the damp chamber one could find where ascospores had oozed out of certain perithecia and collected in amber colored droplets which hardened when

the leaves were dried. A little later more of the leaves became covered with the white hyphomycetous growth similar to that of *Verticillium Buxi*. Rather light pink to dark coral colored sporodochia with setae, resembling very much those of *Volutella Buxi*, also developed. Whether the three forms of fructifications were stages of the same fungus is, of course, problematical. Mrs. Embury later volunteered additional information on this point. She tells us that she had noticed several times during the past summer numerous pinkish pads of fungus growth on the dying leaves and branches, also a whitish powdery growth which often covered the leaves. She thinks that this type of fungus growth more correctly pictures one of the real symptoms of the disease. This would seem to confirm the opinion that their boxwood leaf blight and die-back must be due largely to the fungus *Volutella Buxi* (*Verticillium Buxi*?).

The blight in this planting is now confined to the variety which they refer to as English box. There is still some uncertainty as to the variety. They are using it as an "edging" plant which is allowed to grow a foot or so high. The leaves are very numerous and so form a compact growth of foliage which might well provide just the ideal conditions for the spread of a leaf blight organism. They report that many of the plants originally set out died. A later examination of the planting disclosed many dead or dying stems, all with blighted leaves. Ascocarps in all stages of maturity were present. Leaves still green also bore ascocarps in the very earliest stages of development. In some cases the color was that characteristic of the Hypocreales. In others, especially where the leaves were still green, the perithecial walls by transmitted light were very dark, even greenish black, so that if Albertini and Schweinitz had such a specimen under examination they would have had good reason for naming their species *Sphaeria atrovirens* var. *Buxi*. Usually, however, the walls are a rusty reddish color. The bush varieties or types in this planting showed no *Hyponectria* blight, but the owners report that they are like a number of others that apparently succumbed to the same disease. An extensive planting of an "edging box" at the Memorial Monument, Bronx, New York City, is free from all diseases. It seems to be a different variety.

The large box plants in that collection have been provided with excellent winter protection. A more extensive study of the whole question of varietal susceptibility, effects of winter injury, wind and sun injury, as well as lack of adequate and correct use of fertilizers will be necessary before a correct picture of these box troubles can be secured.

The question arises whether or not we have two leaf blights or die-backs of boxwood, one caused by an ascomycete which is readily identified as *Hyponectria Buxi* (DC.) Sacc., and the other caused by *Nectriella Rousseliana* (Mont.) Sacc., both having similar conidial stages. Examination of the specimens in the herbarium of The New York Botanical Garden proves that both species of ascomycetes are frequently associated with boxwood leaf blight and that the perfect stages of the causal organisms are entirely different. The only specimen of *Hyponectria Buxi* from America in our herbarium is that originally collected by F. A. Mulford at Hempstead (L. I.), New York, Nov. 27, 1907. The packet is labeled simply *Sphaeria Buxi*. It is accompanied by a note as follows: "Parasitic on box; spray when first appears next season with weak Bordeaux Mixture and repeat every 3-4 wks, or as it reappears. Cut off and burn all affected shoots before growth begins again. Better do it now." This is a fine specimen and the disease symptoms are exactly like those shown by the collection from East Hampton, New York. Some of the sunken or collapsed ascocarps which are subepidermal had matured asci with hyaline one-celled spores. This Mulford collection is certainly *Hyponectria Buxi* (DC.) Sacc., although no *Volutella* or *Verticillium* growth can be seen on the leaves.

Among the other specimens of *Hyponectria* is No. 1280, Desmazières, Plantes Crypt. France. The specimen is labeled *Sphaeria Buxi* nob. Desmazières endeavors, in a lengthy note accompanying the specimen, to prove that his own specimen is not the *Sphaeria Buxi* of De Candolle. He says that whatever fungus De Candolle had it is not his (Desmazières'). It must be admitted that De Candolle's description was rather sketchy. Weese<sup>3</sup> agrees with Desmazières. Saccardo, however, who made a special study of this question, has accepted the De Candolle

<sup>3</sup> Mitt. Bot. Inst. Tech. Hochs. Wien 10: 87-90. 1933.

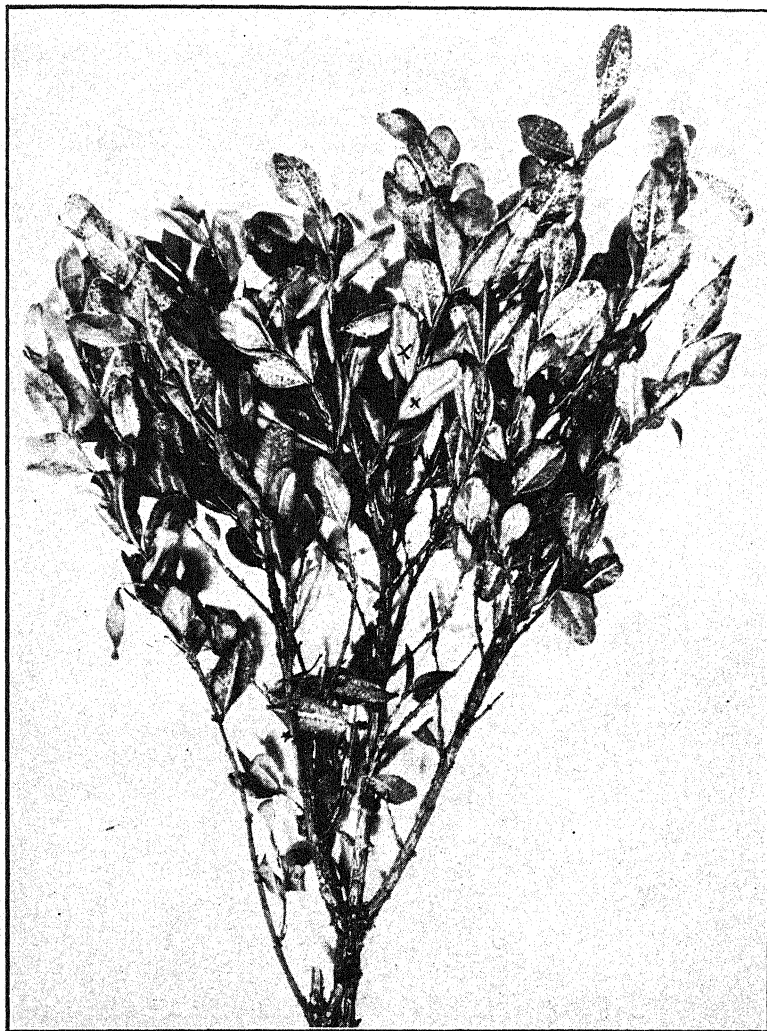


FIG. 1. Leaf blight of boxwood caused by *Hyponectria Buxi* (DC.) Sacc. The topmost leaves were evidently the first to become infected. Several leaves lower down and at the left were still green although most of them bore evidence of the early stages in the development of ascocarps. Two leaves marked "x" at the center are examples of a few green leaves which showed no evidence of infection. Evidently the disease is a leaf blight rather than a leaf spot disease. Slightly reduced in size.

interpretation as the basis for the specific name *Buxi*, and he has, Fungi Ital. No. 200, illustrated this fungus under the name *Hyponectria Buxi* (DC.) Sacc. *Sphaeria atrovirens* var. *Buxi* of Albertini and Schweinitz may or may not actually be the same. Rabenhorst-Winter Fungi europaei, No. 2864, labeled *Hyponectria Buxi* (DC.) Sacc., represents another collection.

A leaf disease of box has been reported in the United States under the names *Laestadia Buxi* (Desm.) Sacc. and *Guignardia Buxi* (Fuckel) Feltz. We have seen no specimens representing these two collections. No. 84, Krieger, Schäd. Pilze, *Laestadia Buxi* (Fuckel) Sacc. has many subepidermal ascocarps dotting the under sides of leaves, some of which are still green. Some leaves bear *Verticillium*. No. 2938, Sydow, Mycotheca marchica *Laestadia Buxi* (Fuckel), shows in addition to ascocarps, a *Verticillium* growth on some leaves. Both collections are *Hyponectria Buxi* (DC.) Sacc., as is No. 178 Briosa e Cavara, Funghi Par., *Laestadia Buxi* (Desm.) Sacc., which illustrates the injury as that of a spot disease.

To return now to leaf blight and die-back of the type heretofore attributed to *Volutella Buxi*, the perfect or ascocarpic stage of which has usually been said to be *Nectria Rousseliana*. The genus *Nectria*, as now understood, includes those species which have two-celled ascospores, while corresponding types with one-celled spores are placed in the genus *Nectriella* Sacc. (*Pseudonectria* Seaver). We find in our herbarium a number of collections of diseased box leaves which carry the label "*Nectriella Rousseliana* (Mont.) Sacc." The two collections labeled *Nectria Rousseliana* are included in the *Nectriella* cover. Krieger, Fungi Sax. No. 427; Roumeguère, Fungi Sel. Exs. No. 6252; Rehm, Ascom. No. 934, are examples of *Nectriella Rousseliana* (Mont.) Sacc. These all show numbers of amber-colored superficial perithecia which are easily dislodged. Some of them have a well marked ostiole and some appear to bear a few hyaline hairs. While many of the perithecia are cracked open and empty, others contain mature asci with eight one-celled spores. Frequently the same leaves bear remains of sporodochia of a *Volutella*, but it is difficult to find attached spores. A *Verticillium* ? hyphomycetous growth is often present.

Saccardo, *Fungi Ital.* plates 199 and 200, illustrates side by side *Nectriella Rousseliana* (Mtgn.) Sacc. and *Hyponectria Buxi* (DC.) Sacc. His figures bring out clearly the essential differences. The first, No. 199, figures a typical superficial ascocarp of the *Nectria* type. The second, No. 200, shows diagrammatically subepidermal ascocarps of the *Hyponectria* type.

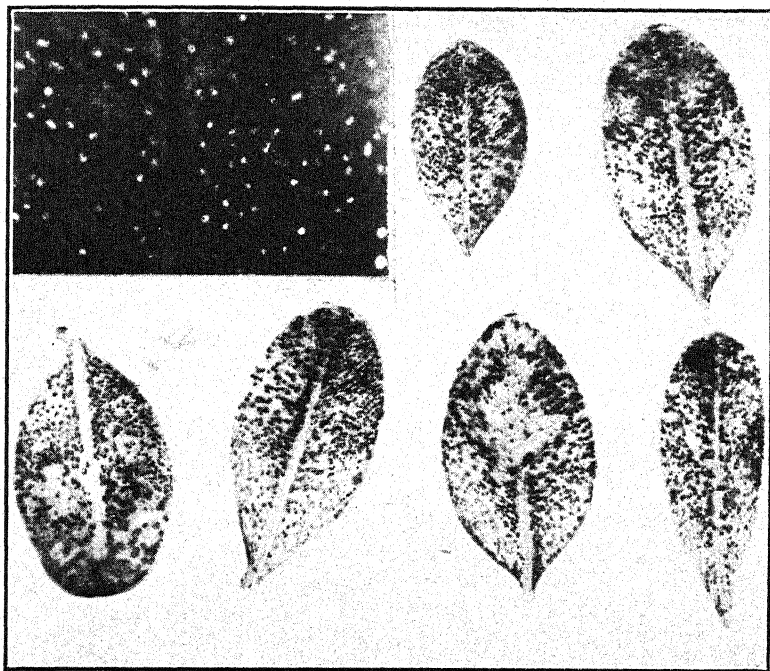


FIG. 2. *Hyponectria Buxi* (DC.) Sacc. Upper left. Under side of part of a dry leaf of boxwood photographed by transmitted light to show the pits which represent the translucent shrunken and collapsed ascocarp contents. This is the condition in which the ascocarps pass the winter. Asci are usually present. Some already contain ascospores but in most ascocarps the asci will probably pass the winter in the uninucleate resting stage,  $\times 12$ . The other leaves show on the lower side the raised or pimply spotting ascocarps after the leaves have been kept in a moist chamber for a day or two,  $\times 2\frac{1}{2}$ .

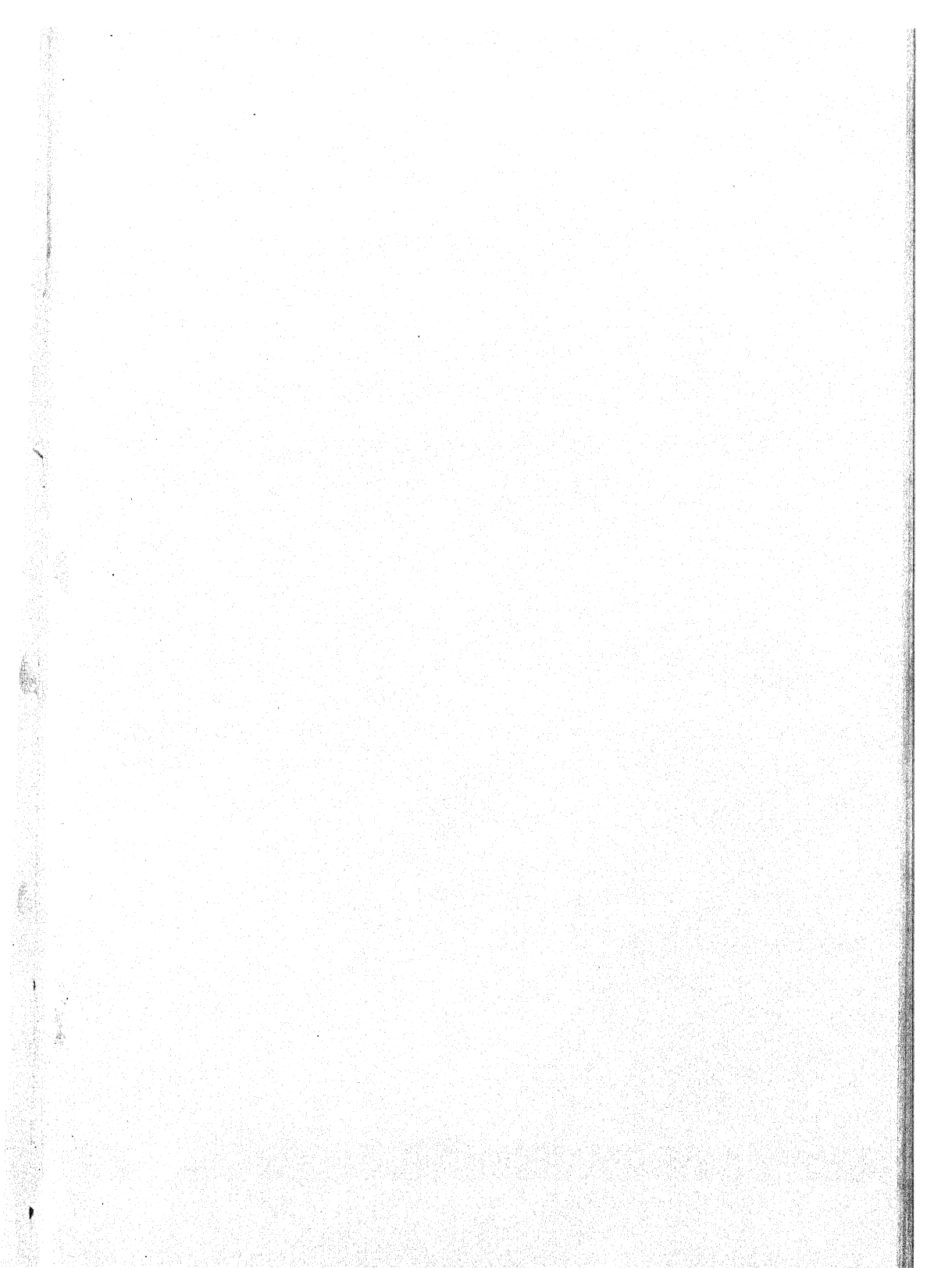
In our herbarium there are several specimens of *Verticillium Buxi* (Lk.) Sacc. Several of them were collected by F. W. Anderson at Washington, D. C. One was collected by L. E. Miles at Corinth, Massachusetts. There is also one collection of *Volutella Buxi* Berk. from Philadelphia, Pa. These specimens

were examined but no ascocarps of either *Nectriella* or *Hyponectria* were found.

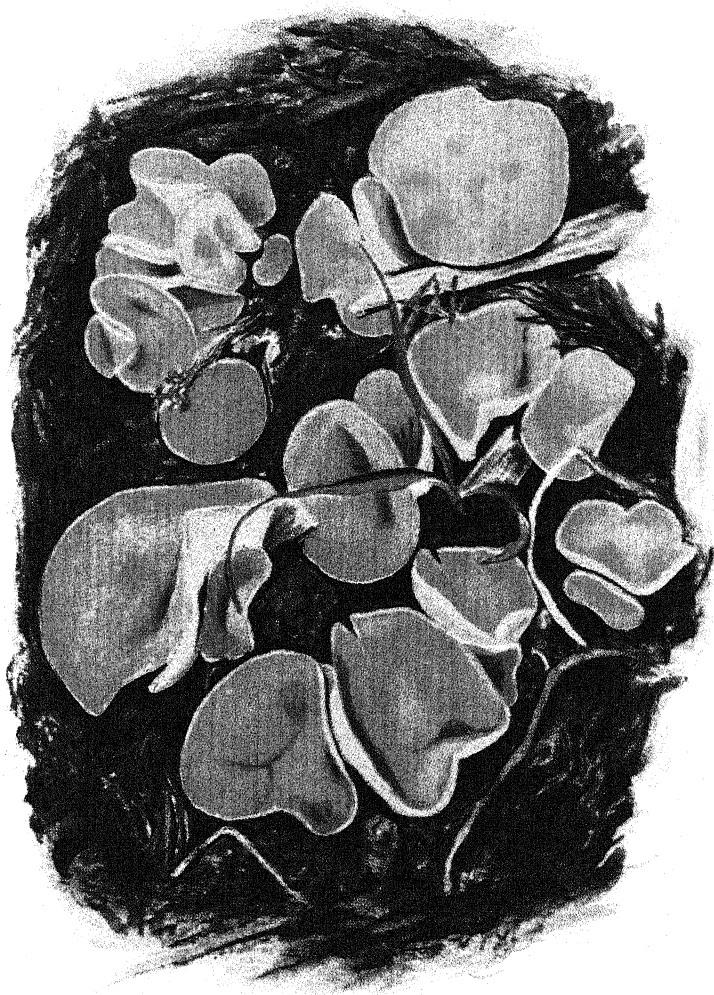
The Embury specimens are also interesting because of the ease with which various stages in the development of pycnidia of *Macrophoma Candollei* can be followed in damp chamber cultures. Most pycnidia mature only the very large *Macrophoma* type of conidia, while others, even on the same leaf, are filled with great quantities of microconidia. These are borne on very definite, rather long conidiophores similar in arrangement to those which bear macroconidia. More rarely, still other pycnidia develop quantities of both the *Macrophoma* and the microconidial types of conidia. This phenomenon is not unknown in the fungi. Pycnidia of *Sphaeropsis malorum* occasionally develop two kinds of conidia, the one large, the other small. Spermogonia, micropycnidia, of *Phoma carpogena* may develop a few large conidia along with myriads of spermatia or microspores.

It is clear that all this confusion in regard to boxwood leaf blight and die-back can not be clarified until cultural studies of both the *Nectriella* and *Hyponectria* are made, beginning in each case with single ascospores. Such studies followed by infection experiments will enable one to determine the status of *Volutella Buxi* and *Verticillium Buxi* and will no doubt give us some other highly interesting information.

THE NEW YORK BOTANICAL GARDEN







ALEURIA AURANTIA

# MYCOLOGIA

OFFICIAL ORGAN OF THE MYCOLOGICAL SOCIETY OF AMERICA

VOL. XXXVI

MAY-JUNE, 1944

No. 3

## ALEURIA AURANTIA

FRED J. SEAVER

(WITH COLORED ILLUSTRATION)

Commonly known by the name *Peziza aurantia* this is one of larger as well as one of the most attractive of the operculate cup-fungi. Unfortunately, the color does not persist long on drying or when preserved, and it then becomes necessary to rely on other characters in diagnosing the species. Nature has been very considerate and provides us with another character less easily observed, but no less definite and dependable. The spores when mature are covered over with a coarse net-work of ridges giving them a reticulate surface. It is this character which has been used in segregating the genus *Aleuria* of which this species is the type.

The plants of this species occur throughout temperate North America, and may occur singly and regular in form or they may give rise to congested masses, the individuals becoming much contorted and twisted. McIlvaine states: "At Mt. Gretna, Pa. patches of it twenty feet long made the ground along a road on the margin of a woods golden with its clusters." It grows usually on bare ground and often on clay banks and may be found from May until late autumn.

While the writer has not used this fungus as food, McIlvaine claims to have eaten it for fifteen years. At any rate like most of the cup-fungi it is not poisonous and can be eaten with impunity.

For a complete description and synonymy see North American Cup-fungi, page 97.

THE NEW YORK BOTANICAL GARDEN

[MYCOLOGIA for March-April (36: 123-222) was issued April 1, 1944.]

# STUDIES ON FILM-FORMING YEASTS. ACID PRODUCTION BY ZYGOPICHIA AND ZYGOHANSENULA<sup>1</sup>

WALTER J. NICKERSON

(WITH 4 FIGURES)

Film-forming yeasts are of widespread occurrence and of considerable economic importance. Representatives belong to the sporogenous genera *Pichia*, *Zygopichia*, *Hansenula*, *Zygo-hansenula*, and *Debaryomyces*; and to the asporogenous genus *Mycoderma*. They are frequently found growing on salt brines used for the storage of various food products; Mrak and Bonar (1939) in a study of the taxonomy and salt tolerance of certain film yeasts include a good bibliography. Fermented beverages of many types have yielded new forms. In some cases a particular quality of the drink has been attributed to these yeasts (e.g., the "flor" of sherry, cf. Hohl and Cruess, 1939) while in other cases they have been looked upon as nuisances because of their ability to oxidize ethanol rapidly or to impart "off-flavors." Danzig beer, English cider, native African wine, and Mexican pulque are but a few of the aqueous habitats. Ruiz Oronoz (1936) isolated *Zygopichia farinosa* from the exudate of ash trees in Mexico.

In connection with taxonomic work (1944) on the genus *Zygosaccharomyces*, wherein it was found advisable to transfer certain misplaced film-forming species to *Zygopichia*, the author became interested in the close relationship between the genera *Pichia* and *Hansenula*. Mrak, Phaff, Vaughn, and Hansen (1942) have pointed out that only the ability to utilize nitrate now separates the two genera and they believe it may become necessary to combine the two genera. (*Zygopichia* and *Zygo-hansenula*, along with *Zygosaccharomyces*, occupy the rank of subspecies in Stelling-Dekker's (1931) system, each being separated from the parent

<sup>1</sup> Grateful acknowledgment is made of aid by a grant from the Cyrus M. Warren Fund of the American Academy of Arts and Sciences, and by a grant from the Faculty Research Fund of Wheaton College.

species by having gametic conjugation preceding spore formation.) The discovery of new species of *Pichia* and of *Hansenula* has been responsible for so broadening each of the generic limits that today there is considerable overlap on all points except that of nitrate utilization, which is negative with *Pichia* and positive with *Hansenula*.

Since yeasts apparently must reduce nitrate before utilizing it, species of *Pichia* should give a negative test for the presence of nitrite, a reduction product of nitrate, in the culture medium. However, if nitrate is to be reduced, a suitable hydrogen donor must be present. Ordinarily in tests for nitrate utilization (auxanograph) or for nitrite (*cf.* Manual of Methods, 1942) glucose is the hydrogen donor; yet it is possible for some organisms (species of *Pseudomonas* for instance) to reduce nitrate with a suitable hydrogen donor but not with glucose, that is the requisite dehydrogenase is not present or developed. While one could test all of the many substances that are suitable carbon sources for *Pichia* growth in an attempt to find a suitable hydrogen donor for nitrate reduction (if successful, decreasing again the distance between the two genera), only ethanol and glycerin were studied.

Some of the aspects of acid production by various species of *Zygomichia* and *Zygothansenula* were examined. The physiology of acid production by yeasts is not very well understood and, with a few exceptions, little work has been done on the metabolism of film-forming species.

#### CULTURES USED

*Zygomichia Chevalieri* (Guilliermond) Klöcker.

Culture M 1, kindly supplied by Dr. E. M. Mrak.

Culture H 175, kindly supplied by Dr. D. H. Linder; this strain originally No. 617 from Guilliermond's laboratory.

*Zygomichia farinosa* (Lindner) Klöcker.

Culture No. 2252 from the Am. Type Culture Collection.

*Zygomichia Chevalieri* var. *Andersonii* Nickerson (syn. *Zygosaccharomyces bisporus* Anderson).

Culture H 177, kindly supplied by Dr. D. H. Linder; this strain originally No. 569 from Guilliermond's laboratory.

*Zygothansenula californica* Lodder.

Culture from Dr. Mrak as No. 111.

*Hansenula saturna* (Klocker) Sydow.

Culture H 85, supplied by Dr. Linder.

*Hansenula anomala* (Hansen) Sydow.

Culture H 86, supplied by Dr. Linder.

*Pichia membranefaciens* Hansen.

Culture from Am. Type Culture Coll.

#### METHODS

Two day old growths of these yeasts on wort agar (Difco) plates were used to seed the various media employed; the plates were scraped and the cells suspended in sterile M/15  $\text{KH}_2\text{PO}_4$  buffer to a standard photometric density. The experimental culture media consisted of a basal medium with various amendments; composition of the basal medium was as follows: 3.0 g.  $\text{KH}_2\text{PO}_4$ , 3.0 g.  $(\text{NH}_4)_2\text{SO}_4$ , 0.25 g.  $\text{MgSO}_4$ , 0.25 g.  $\text{CaCl}_2$ , 2.0 g. Bacto-peptone, 0.10 g. yeast extract, and distilled water to make one liter. Amendments included glucose and ethanol; recently boiled 95 per cent ethanol was added aseptically to sterile flasks of the basal medium to give the requisite final concentrations; glucose solutions were autoclaved separately and added to the basal medium to give the requisite final concentrations. Fifty cc. Erlenmeyer flasks containing 25 cc. of media were inoculated, incubated at 25° C. and the contents analyzed after seven days.

Total acidity was determined by titrating, after heating, a clear centrifugate of the medium with 0.100N NaOH, using phenolphthalein as indicator. Growth measurements were made using a photoelectric densitometer constructed<sup>2</sup> after the design of Stier, Arnold, and Stannard (1934). Sugar remaining in the medium was determined by Benedict's (1931) method. All

<sup>2</sup> The author wishes to express his thanks to Dr. Glenn A. Shook, Professor of Physics, Wheaton College, for his invaluable aid in construction of this apparatus. The method of Stier, Arnold, and Stannard was simplified by the use of Photronic cells thus eliminating the 90 volt battery. Computation was practically eliminated by making the resistance  $R_2$  1000 ohms when sterile media was in the tube; balance being made with  $R_1$ . When a suspension was in the tube balance was made with  $R_2$ ,  $R_1$  remaining constant.

analyses were made in triplicate on duplicate flasks; since the individual determinations were in good agreement, only averages are presented.

#### ACID PRODUCTION

##### ETHANOL SERIES.

Three yeasts were used: *Zygopichia Chevalieri* var. *Andersonii*, *Z. Chevalieri* (M 1), and *Zygo Hansenula californica*. As will be seen in figure 1 acid production by the two varieties of *Zygo-*

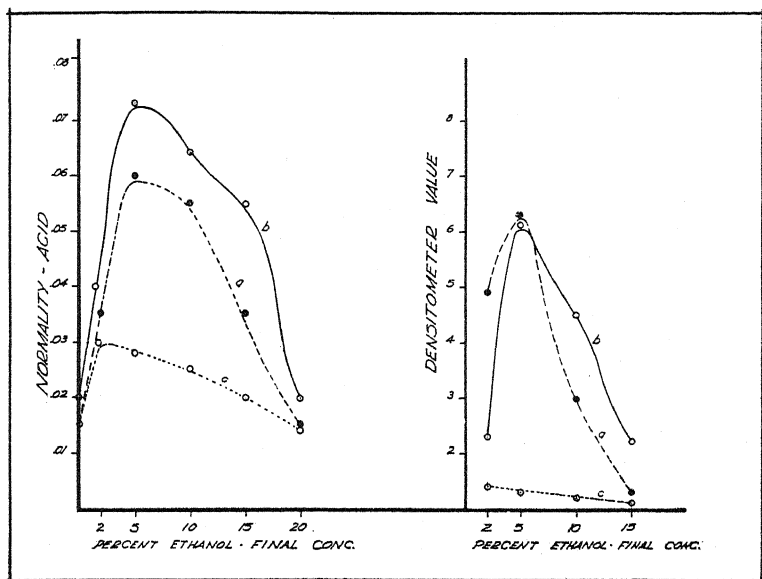


FIG. 1. Acid production (left) and yeast growth (right) with different concentrations of ethyl alcohol. Curve "a" for *Zygopichia Chevalieri* var. *Andersonii*; "b" for *Zygopichia Chevalieri* (M1); and "c" for *Zygo Hansenula californica*. Initial normality of media was 0.015.

*pichia* is quite high and the curves for their amount of growth are similar to the graphs of acid production. As is evident, the basal medium with 5 per cent ethanol furnishes an excellent growth medium for these two yeasts. With *Zygo Hansenula californica* on the other hand, the ethanol medium is a poor one for growth; here this yeast makes a miserable pellicle and grows as a faint sediment. It produces but a slight increase in acidity over that of the medium.

## GLUCOSE SERIES.

Since the two varieties of *Zygopichia* employed in the ethanol series responded so similarly, only *Z. Chevalieri* var. *Andersonii* and *Zygohansenula californica* were used.

On this medium the species of *Zygopichia* made little sediment and, as figure 2 shows, its growth was light. Pellicle formation was good, however, up to 30 per cent glucose; 42 per cent showed scattered islands rather than a complete film. Figure 2 shows

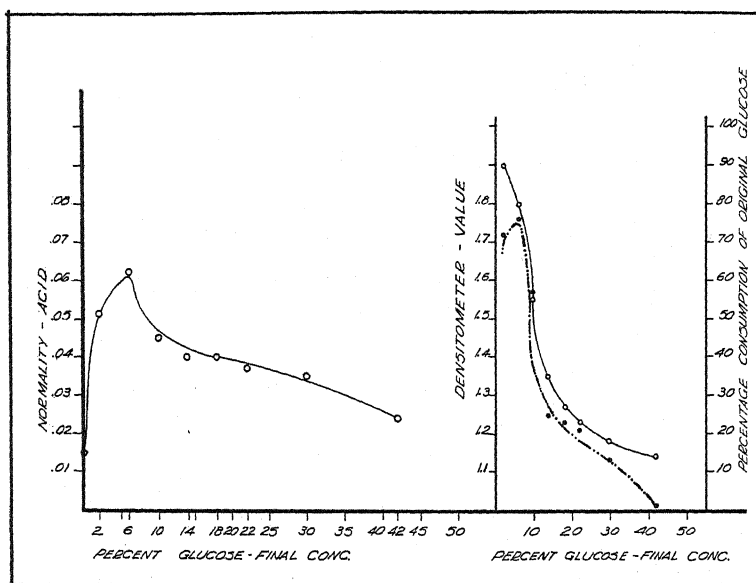


FIG. 2. Acid production (left) and yeast growth (right, dotted line) and glucose consumption (right, solid line) by *Zygopichia Chevalieri* var. *Andersonii* with different concentrations of glucose.

the decrease in growth as compared with the ethanol medium did not result in a corresponding decrease in acid production; rather, the peaks of the curves for the two series are nearly identical. It would seem that with this species pellicle cells are most active in acid production.

With *Zygohansenula* an entirely different response is made to the glucose medium than to the ethanol. Figure 3 shows acid production to be appreciable in all concentrations up to 45 per cent (the highest used), and growth to be excellent. Densitom-

eter values given are for one-half the culture concentration (5 cc. diluted with 5 cc. of sterile media) since the density of the cultures with the best growth were beyond the range of the instrument. *Zygothansenu* when inoculated into the sugar media rapidly made a pellicle and simultaneously developed a dense sediment. The pellicle did not creep up the wall of the flask in the fashion characteristic of *Zygopichia* in this medium.

#### NITRATE UTILIZATION AND REDUCTION

A comparison of nitrate utilization as evidenced by growth, and the presence of nitrite in the culture medium is given in table 1. The basal medium was used with a substitution of

TABLE 1  
COMPARISON OF NITRATE UTILIZATION AND NITRATE REDUCTION BY SPECIES  
OF *Pichia* AND *Hansenula*  
See text for description of methods.

Organism	Pellicle formation	Sedimentary growth	Gas production	Nitrite test
<i>Zygothansenu californica</i> . . .	—	+	—	+
<i>Hansenula saturna</i> . . . . .	islands	+	—	+
<i>Hansenula anomala</i> . . . . .	+	+	+	+
<i>Zygopichia Chevalieri</i> (M1) . .	islands	—	—	—
<i>Zygopichia Chevalieri</i> (H175) ..	—	—	—	—
<i>Zygopichia farinosa</i> . . . . .	islands	—	—	—
<i>Pichia membranefaciens</i> . . . . .	—	—	—	—

6.0 g.  $\text{KNO}_3$  for ammonium sulfate and peptone; 2 per cent glucose was the carbon source. The usual sulfanilic acid and alpha-naphthylamine test for nitrite was used; in cases where nitrite tests were negative a Zinc dust test was performed once in each series to preclude the obscure possibility that nitrate had been reduced beyond the nitrite stage. It will be seen that tests for the presence of nitrite agree with those for nitrate utilization and have simplicity in their favor.

When 2 per cent ethanol was substituted for glucose as the carbon and hydrogen source in the above medium no appreciable



difference in results was obtained; ethanol as a source of hydrogen did not result in the reduction of nitrate by any species of *Pichia* employed; the same held true when 2 per cent glycerin was used. Thus it would seem that it is not the absence of a dehydrogenase mechanism but of the nitratase system itself that is involved.

#### OBSERVATIONS ON FILM FORMATION

The process of film formation by microorganisms is a fascinating one—both to watch, and in view of the great complex of activity which must be involved.

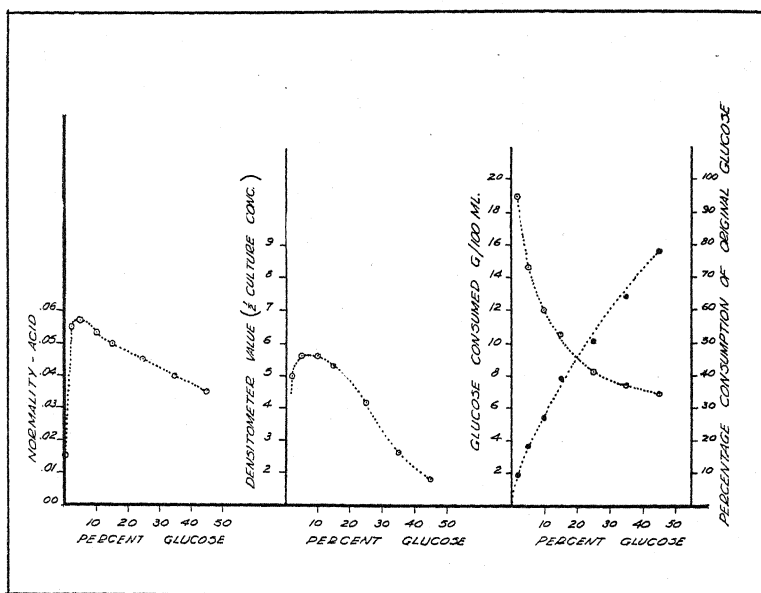


FIG. 3. Acid production (left), yeast growth (center), and glucose consumption (right) by *Zygothansula californica* with different concentrations of glucose. Densitometer values given are for a 50 per cent dilution. Compare growth and acid production in figure 1 "c." Glucose consumed (solid circles), per cent consumption (open circles).

When *Z. Chevalieri* var. *Andersonii* (or any of the other species of *Zygothansula* mentioned) is inoculated into a flask containing a 2 per cent glucose-basal medium, the beginnings of a film can be observed after 12 hours at 25° C. An island (usually only one) of cells appears in the center and the surface is rapidly covered

with a thin film. Figure 4 gives the result of measurements on the surface area of a film formed under the conditions just described; at 48 hours the film was complete. The curve obtained resembles a portion of the familiar sigmoid growth curve. While media with a surface area as great as 18,000 square mm. have been inoculated with species of *Zygopichia*, the complete sigmoid curve has not been obtained, *i.e.*, the logarithmic phase persisted

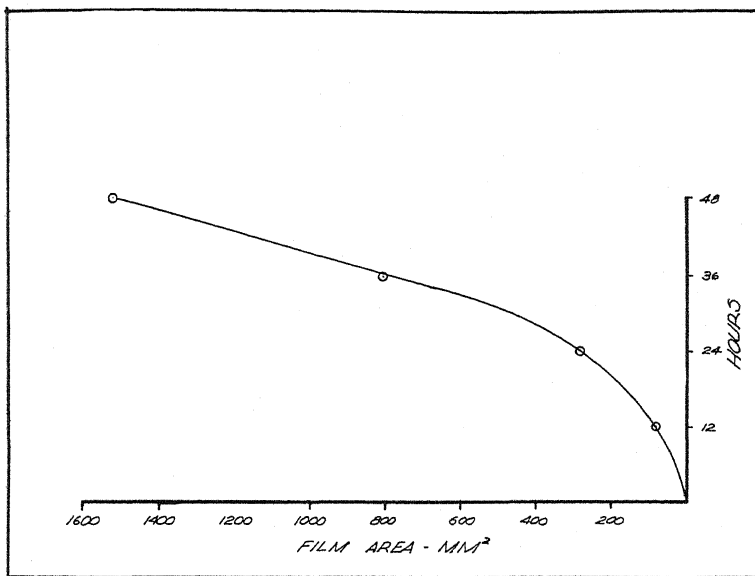


FIG. 4. Rate of growth of pellicle formed by *Zygopichia Chevalieri* var. *Andersonii* on a 2 per cent glucose medium. Surface of the liquid completely covered by 48 hours.

until the surface was covered. At the other extreme, films were formed quite readily in test tube culture with suitable media.

With *Zygopichia* there is little tendency to form a sedimentary deposit in a flask, and what little does form seems to fall from the surface growth. With *Zygohansenula* on the other hand, a good pellicle is formed in a glucose medium but this appears to be incidental to the growth of the yeast as a heavy sediment. This contrast in behavior of these two yeasts during growth is reflected in the photoelectric densitometer measurements which are about 3.5 times as high (logarithmic scale) for *Z. californica* as for *Z. Chevalieri* var. *Andersonii*.

Another difference between the mode of film formation by *Zygothansenula* and *Zygopichia* is seen in the nitrate test medium previously mentioned. Here *Zygothansenula* grows well, reduces nitrate and assimilates it, but the yeast makes little if any pellicle, growing almost exclusively as a sediment. This behavior is in contrast to that in media without nitrate, where growth is equally good, wherein it produces a well defined pellicle. A guess at an explanation for this behavior is that when nitrate is supplied a good hydrogen acceptor is also supplied; cells that might have been on the surface in the absence of nitrate (using atmospheric oxygen as the hydrogen acceptor) are in some, non-teleological (!), fashion restrained, inhibited, or relieved of the necessity of forming a film, *i.e.*, being at the surface. It should be borne in mind that in the nitrate medium *Zygothansenula* makes a good growth. *Zygopichia* in the same medium makes a miserable growth, as pellicle exclusively, at the expense of the available nitrogen in the yeast extract supplied; nitrite tests are invariably negative. Proof that the small growth made was at the expense of the yeast extract, and in no way connected with nitrate utilization, was obtained by preparing a purely synthetic medium replacing the yeast extract with known chemicals having growth nutritive functions: biotin, inositol, thiamin, pantothenic acid, and pyridoxin. No growth was made in this synthetic medium.

#### DISCUSSION

This paper has attempted to point out some of the characteristics of acid production, film formation, and nitrate utilization of a few species of film-forming yeasts. Whether any of these characteristics possesses real taxonomic value necessitates the study of more isolates in all the genera concerned. From the evidence presented, however, it appears that though nitrate utilization may be the only criterion on which there is no overlap between the genera *Pichia* and *Hansenula*, it is indicative of a fundamental dissimilarity in the enzymatic make-up of the two groups—the former more oxidative in nature, the latter more reductive. While there are such species as *Pichia fermentans* and *Zygopichia farinosa* which are able to cause fermentations, thus

creating a resemblance to *Hansenula*, these should serve to emphasize that genera of yeasts are not clearcut affairs without transitional forms.

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## VARIATIONS IN SINGLE ASCOSPORE ISOLATES OF *SCLEROTINIA SCLEROTIORUM*<sup>1,2</sup>

DONALD M. COE

(WITH 3 FIGURES)

The study of heterothallism in the genus *Sclerotinia* has received recent and intensive investigation by Drayton (1) and Gregory (4) and in some instances they have demonstrated certain species to be homothallic whereas other species are heterothallic. Keay (7) has shown *Sclerotinia sclerotiorum* (Lib.) Masee, *S. Trifoliorum* Erik. and *S. minor* Jagger capable of the production of normal apothecia from single ascospore isolates which confirmed Henson's report (6) of apothecial production from similar isolates of *S. sclerotiorum* and *S. Trifoliorum*. Godfrey (3) has also demonstrated homothallism in *S. Ricini* Godfrey, and more recently a self-fertile, homothallic condition has been reported for *S. sativa* Drayton and Groves (2). This paper is to report the results of certain preliminary studies with single ascospore isolates of *S. sclerotiorum* in which self-fertility and homothallism for sex is again demonstrated and also wherein a segregation for cultural and other characters was encountered. Variation in cultural characters of single ascospore isolates of an unnamed *Sclerotinia* which is the perfect stage of *Botrytis cinerea* has already been reported by Groves & Drayton (5).

### ISOLATION OF SINGLE ASCOSPORES

During the spring of 1940, 31 randomly selected ascospores from an isolate of *Sclerotinia sclerotiorum* from cucumber and designated as isolate 8265 were cultured on potato-dextrose agar preparatory to starting giant oat cultures for obtaining sclerotia

<sup>1</sup> This work is a portion of a thesis submitted to the State College of Washington in partial fulfillment of the requirements for the degree of Doctor of Philosophy, January 29, 1943.

<sup>2</sup> The writer wishes to express his sincere appreciation to Dr. F. D. Heald, under whose direction this work was conducted, for his generous help and advice during the course of the work and the preparation of the manuscript.

for apothecial production. It was noted that a great dissimilarity existed in the general appearance of these isolates and that they could be readily divided into two groups of constant characters. Of the 31 isolates, 14 had every appearance of the parent isolate and were thereafter designated as the N or normal type and the remaining 17 were designated as the A or aberrant type. These differences will be described later.

The method used in isolating the single ascospores was to allow a mature apothecium to forcibly discharge ascospores onto plates of 3 per cent water agar. After incubating these plates for 8 to 12 hours at room temperature in order to allow short germ tubes to develop, the single ascospores along with a very small portion of the agar substratum were removed from thinly seeded portions of the plate. This was readily accomplished by cutting the agar with a fine, curved platinum needle and "scooping" out a small block of the agar substratum with a single, germinating ascospore on its surface. The use of a stereoscopic binocular microscope permitted direct observation of all manipulations, thus eliminating the possibility of obtaining even a small fragment of mycelium from a neighboring sporeling. The isolates thus obtained were designated as 0-1 to 0-31 inclusive as they were isolated and numbered consecutively without regard to the type of growth which followed.

#### DESCRIPTIVE DIFFERENCES

##### CULTURAL

Isolates of the N or normal type, when growing on potato-dextrose agar, resembled in every respect the parent type isolate from which they originated. Growth rates were approximately the same and the mycelium quickly covered the entire surface of the agar. The mycelial growth was floccose to patchy with the density of the mat increasing as it reached the periphery of the Petri dish. Numerous sclerotia were formed and they were of normal size, shape and color.

Isolates of the A or aberrant type, when grown at the same time as the N type, exhibited a much slower radial growth, and, after 5 days on potato-dextrose agar at 19-20° C., averaged 60 millimeters in diameter whereas the N isolates had grown in all cases

to the edge of the Petri dish (90 mm.). After 10 days on potato-dextrose agar plates, both types had entirely covered the surface of the agar, and sclerotia had just begun to form in the A type isolates, whereas they were nearing maturity in the N type isolates.

The character of the mycelial growth of the A type isolates was distinctly more cottony than the N type and formed a thick uniform mat over the entire surface of the medium. This mat was so dense, especially at the surface of the agar, that the passage of light was excluded and in test tube culture assumed a distinct brown color at the agar surface. The sclerotia produced by the A type isolates were few in number, more irregular in shape and showed a strong tendency to be flattened and depressed on the upper surface in contrast to the domed shape of the N type sclerotia. Cultural characters of the A and N types are summarized in figure 2.

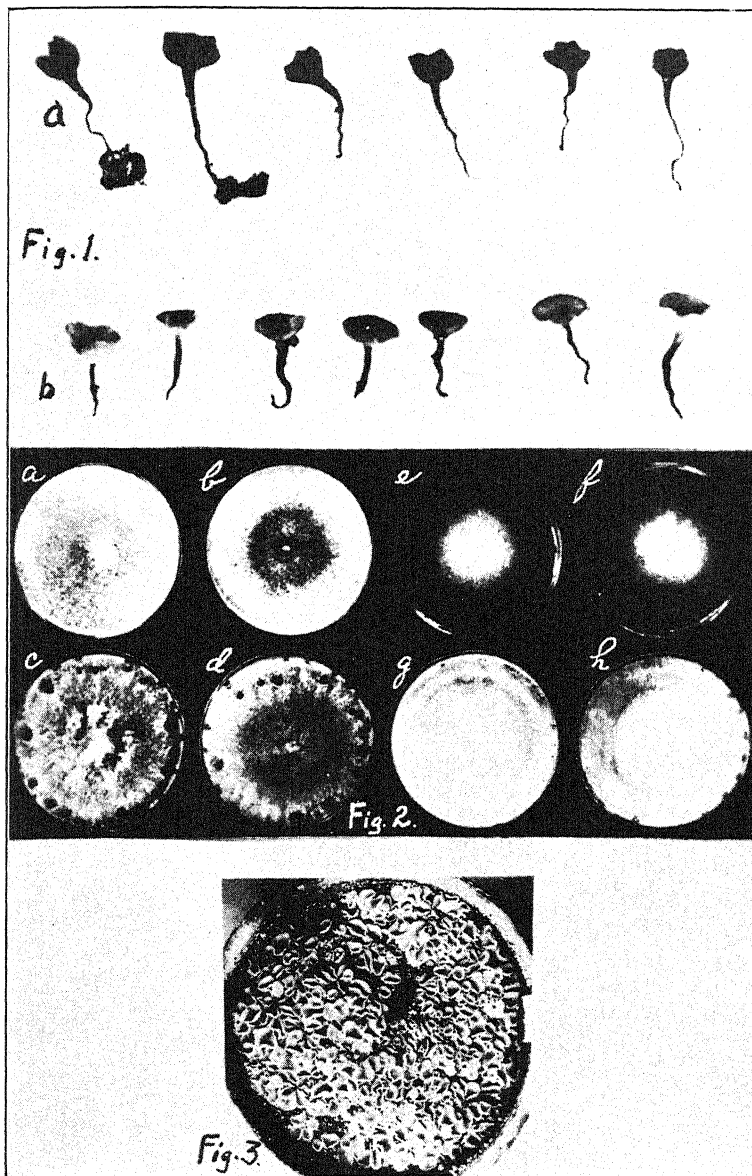
In the giant oat cultures used for growing sclerotia for the production of apothecia, these same differences were evident. The bulk or mass of sclerotia obtained from the N type isolates was approximately four times greater than from the A type isolates of the same bulk and age.

#### APOTHECIAL PRODUCTION

Sclerotia grown from both N and A type isolates during the fall of 1940 were planted in the greenhouse on December 6, 1940, in separate sand cultures which included two of the A type and three of the N type. The first apothecia from these pot cultures appeared on February 4, 1941, and the last culture to start apothecial production was on February 20, 1941. This slight difference shows that the two types are not different in the length of

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FIG. 1, *a*, apothecia of *S. sclerotiorum* of the A or aberrant type produced from single spore isolate; *b*, N or normal type apothecia from single spore isolate from the same parent isolate as *a*. FIG. 2, *a*, *b*, single ascospore isolates 0-11 and 0-10 of *S. sclerotiorum* respectively of the N type after growth for 5 days on potato-dextrose agar at 19-20° C.; *c*, *d*, the same cultures respectively after 10 days growth; *e*, *f*, A or aberrant type isolates 0-1 and 0-9 derived from single ascospores of *S. sclerotiorum* after 5 days of growth; *g*, *h*, the same cultures after 10 days growth. FIG. 3, a pot of N type apothecia produced by single ascospore isolate 0-10 of *S. sclerotiorum*.



FIGS. 1-3.



time necessary for the production of apothecia under these conditions. Similar results from plantings during the next winter substantiated this observation.

One of the more striking differences between these two types of *Sclerotinia sclerotiorum* is the greater number of apothecia produced from a given mass or bulk of sclerotia from an N type isolate than from the same bulk of sclerotia from an A type isolate. On November 29, 1941, 9 pot cultures of sclerotia which originated from single ascospore isolates were started in the greenhouse. Four of these isolates were of the N type, and five were of the A type. From the results shown in table 1, the great difference in

TABLE 1  
NUMBER OF APOTHECIA PRODUCED BY N TYPE AND A TYPE SINGLE ASCOSPORE  
ISOLATES OF *Sclerotinia sclerotiorum* No. 8265 IN SAND CULTURES IN  
GREENHOUSE AT PULLMAN, WASHINGTON, WINTER AND  
SPRING OF 1941-42

Isolate	Type	Quantity of sclerotia planted	Date apothecial production began	Number of apothecia		
				Expanded	Aborted	Total
0-26	A	5 gms.	Feb. 4	6	5	11
0-20	A	20 "	" "	15	20	35
0-9	A	17 "	" "	167	47	214
0-24	A	20 "	Mar. 28	60	27	87
0-1	A	20 "	Feb. 4	77	152	229
0-10	N	20 "	Feb. 13	728	126	854
0-11	N	20 "	Mar. 28	909	166	1075
0-15	N	20 "	Mar. 13	1350	71	1421
0-5	N	20 "	" "	928	151	1079

apothecial-producing ability is evident. All cultures produced a number of aborted or non-expanded apothecia which were recorded separately at two week intervals at which time all mature apothecia were removed without disturbing the sclerotia in the sand.

No further data were taken after June 6, 1942, although all of the pots were still producing a few apothecia. The pots were then allowed to become dry and remained so until October 1, 1942, during which time the temperatures became high and exceeded 100° F. on many days. Within two weeks after water was again added to the pots or by October 15, some of the

sclerotia resumed apothecial production, but in all instances only the N type isolates did so.

Figure 3 shows a pot of apothecia produced from sclerotia of single ascospore isolate 0-10. They are indistinguishable from the apothecia produced by the parent isolate 8265.

#### APOTHECIAL CHARACTERS

In addition to the cultural growth and the marked difference in apothecia-producing ability of these two types, the apothecia exhibited still another striking differential criterion. In fact, macroscopically, the apothecia produced by these two single ascospore types are more different than are the apothecia of *Sclerotinia sclerotiorum* and *S. Trifoliorum*.

TABLE 2

COMPARISON OF FIFTY ASCUS AND ASCOSPORE MEASUREMENTS FROM SINGLE SPORE ISOLATES 0-5 AND 0-1 OF *Sclerotinia sclerotiorum* No. 8265

Isolate	Dimensions in microns	
	Ascospores	Asci
0-5 (N type)	(1) 12.61 $\times$ 6.63	135.99 $\times$ 8.06
	(2) 11.56-14.40 $\times$ 5.66-9.02	117.39-150.42 $\times$ 6.90-8.97
0-1 (A type)	(1) 12.30 $\times$ 6.89	134.76 $\times$ 7.91
	(2) 11.33-14.16 $\times$ 6.37-7.32	117.30-154.56 $\times$ 6.90-8.97
(1) Average, (2) Range.		

The apothecia of the A type are darker colored than the N type and the blackening of the stipe extends in some instances well onto the lower surface of the disc. The hymenium is dark brown rather than a light tan as in the N type. The margin of the discs is generally ruffled rather than symmetrical and these are seldom fully expanded as are those of the N type (FIG. 1). In texture, the apothecia of the A type are rather soft and watery as compared to the firm, wax-like texture of the apothecia of type N. Microscopically, the apothecia are also unlike. Crushed hymenial tissue of the A type apothecia exhibits a high ratio of paraphyses to asci in comparison with the N type. The asci and ascospores are more irregular in outline although they compare very closely in size. In table 2 the ascus and ascospore

measurements are presented as recorded from isolates 0-5 (N type) and 0-1 (A type).

#### SINGLE SPORE REISOLATIONS

On May 20, 1942, isolations of single ascospores were made from apothecia produced by the single-spore isolates by the same method used in obtaining the original cultures from single ascospores. The resulting isolates were grown on potato-dextrose agar in parallel with the parent isolates at 19-20° C. and corresponded exactly in all cultural characters to the parent single ascospore isolates from which they originated. Sixty-three second generation single ascospore isolates of the A type were thus obtained and 31 of the N type were grown.

#### DISCUSSION

The significance of the results of these isolations of single ascospores cannot be interpreted fully until more extensive work can be conducted. In addition to confirming previous reports (6, 7) of homothallism in *Sclerotinia sclerotiorum*, the discovery of distinct morphological types suggests that, although this fungus is homothallic for sex, it may be subject to segregation for other characters. That no obvious differences between the parent isolate and the N type isolates were observed introduces a possibility of multiple factors being involved. Continued investigation along physiological and pathological lines may eventually reveal criteria in which the N type differs from the parent type as well as further differences between the A and N types. Lack of time precluded inoculations with the various single ascospore lines.

It is interesting to note that the A type has never been isolated directly from diseased plant material by the author nor by any other investigators on the basis of published reports. This may indicate that the A type is incapable of parasitism, that a sexual union by anastomosis occurs, or that the microconidia of *Sclerotinia sclerotiorum* do have a sexual function. Further substantiation of the view that the A type is possibly nonpathogenic lies in the fact that no published records report a differentiation of single ascospore isolates of *S. sclerotiorum* into two distinct types on a basis which approximates a 50 : 50 ratio and, therefore, that all

cases of infection are caused by either N or parent types. Cultures derived from single ascospores of isolate 8257 of *S. sclerotiorum* (isolated from lettuce) and isolate 32 of *S. Trifoliorum* (isolated from *Lentilla lens*) revealed no differences such as in the case here reported. It is entirely possible that previously reported isolations of single ascospores were from cultures which had been derived from mono-ascosporic infections. However, any definite conclusions regarding the origin of these types or their possible significance must be postponed until further experimental work is performed.

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## NEW NORTH AMERICAN AGARICS

ALEXANDER H. SMITH

The species described herein were collected in various parts of the United States, but the majority were found while the writer was collecting in the Olympic National Park during the fall of 1941. This expedition was part of a larger project involving the agarics of the western United States and was made possible by a grant from the Horace H. Rackham School of Graduate Studies of the University of Michigan. As a part of this expedition, the writer spent several weeks during the summer of 1941 in the vicinity of Payette Lakes, Idaho, and during the season of 1943 Mr. Wm. B. Gruber spent the summer and fall collecting and photographing agarics in the same region. As a result of our combined efforts a number of very unusual species were discovered in this region and are included here. Both my own and Mr. Gruber's collections have been deposited in the Herbarium of the University of Michigan. The color terms within quotation marks are taken from "Color Standards and Color Nomenclature" by R. Ridgway, Washington, D. C., 1912. The color terms not in quotation marks are based on Ridgway's system of nomenclature but do not represent actual comparisons. This is true in particular for such common terms as fuscous, tawny, ochraceous, ferruginous, vinaceous, drab etc.

### ***Agaricus vinaceo-umbrinus* sp. nov.**

Pileus 1-2.5 (3.5) cm. latus, obtusus demum campanulatus vel plano-umbonatus, siccus, fibrillosus vel subfurfuraceus, siccatus vinaceo-umbrinus vel fuliginosus; lamellae liberae, confertae, angustae, umbrinae; stipes 2.5-4 cm. longus, 3-5 mm. crassus, aequalis, siccatus cum pileo concolor; annulus fibrillosus; sporae 6-7  $\times$  5-5.5  $\mu$ ; cheilocystidia subcapitata, 38-52  $\times$  4-5  $\mu$ . Specimen typicum in Herb. Univ. of Mich. conservatum: Legit prope Cisco, Texas, Sept. 15, 1935, E. A. Smith.

Pileus 1-2.5 (3.5) cm. broad, obtuse with an incurved margin when young, expanding to campanulate or plano-umbonate, surface appressed fibrillose-silky or minutely furfuraceous around

the disc, color when fresh not known, when dried evenly "drab" to "light drab" (dark gray) or with a tinge of vinaceous ("sorghum-brown"); flesh thin, pale avellaneous when dried, odor and taste not known; lamellae free, remote in dried pilei, close, narrow, dark blackish brown when dried, edges fimbriate; stipe 2.5-4 cm. long, 3-5 mm. thick, equal, stuffed with a fibrillose pith, colors when fresh not known, when dry concolorous with the pileus above, "sorghum-brown" (dull vinaceous brown) around the base, densely appressed fibrillose up to the fibrillose evanescent superior annulus, fibrillose sheath soon breaking into zones or patches and the fibrils dark drab in color, apex silky and blackish when dried, cortex also very dark colored.

Spores broadly ovoid, bister in KOH,  $6-7 \times 5-5.5 \mu$ , smooth, no apical pore visible; basidia  $19-23 \times 7-8 \mu$ , four-spored, pale olivaceous gray in KOH; pleurocystidia not differentiated; cheilocystidia forming a sterile band on the gill edge, filamentose with a small knob at the apex,  $38-52 \times 4-5 \mu$ , pale olivaceous in KOH; gill trama parallel, the hyphae  $8-15 \mu$  in dia., pale olivaceous brown in KOH; pileus trama homogeneous beneath a cuticle of radially arranged hyphae  $5-9 \mu$  in dia., no clamp connections seen, tramal body of interwoven pale olivaceous hyphae when revived in KOH, hyphae  $5-12 \mu$  in dia.

The species was found scattered to subcespitose on soil under live oak, and is known only from the type locality.

Observations: Although unquestionably a species of *Agaricus*, this fungus has many characters not possessed by any other known American species. The olivaceous color assumed by all parts of the carpophore when sections are mounted in KOH is distinctive and unique in this genus. I know of no other *Agaricus* with similar cheilocystidia. The olive color diffuses through the mounting medium causing the latter to become sordid olivaceous also, and the reaction can thus be observed without the aid of a microscope. The vinaceous color present in the carpophore and the surrounding mycelium, and the very dark color of the dried carpophores are also distinctive but not so unusual for the genus. When dried the carpophores are about as dark as those of *A. echinatus* Fries but, of course, the two can be readily separated by the character of the cuticle of the cap. Unfortunately the colors of the fresh specimens are not known. They were described simply as "dark colored mushrooms." In a situation such as this however, it is important to know the changes that take place

as the development of the carpophores proceed. The relationships of this fungus are difficult to determine, and probably cannot be stated accurately until such time as the agaric flora of our southwest has been more critically investigated.

***Agaricus eastlandensis* sp. nov.**

Pileus 6–10 mm. latus, convexus demum planus, ad marginem appendiculatus, siccus, fibrillosus, albidus demum pallide luteus; lamellae liberae, confertae, angustae, incarnatae dein umbrinae; stipes 10–15 mm. longus, 1.5–2.5 mm. crassus, aequalis vel bulbosus, albidus demum avellaneus, sursum sericeus, deorsum fibrillosus; annulus fibrillosus, albidus; sporae subgloboae vel late ellipsoideae, (8) 9–11  $\times$  7–9  $\mu$ . Specimen typicum in Herb. Univ. of Mich. conservatum: Legit prope Eastland, Texas, Aug. 28, 1938, E. A. Smith.

Pileus 6–10 mm. broad, convex becoming plane, margin at first fringed with fibrils left by the broken veil, surface dry, appressed silky-fibrillose, white or whitish, in age creamy yellowish on the disc, when dried pale buff over all or the disc slightly darker, not changing to yellow when cut or bruised; flesh very thin, white, odor and taste not recorded; lamellae free but approximate to the stipe, close, narrow, dull vinaceous but finally blackish brown, edges even; stipe 10–15 mm. long, 1.5–2.5 mm. thick, equal above a bulbous base, white or whitish but gradually becoming brownish beneath a thin coating of appressed white fibrils, silky above the annulus and tinged pinkish, bulb consisting of a mass of soil held together by a copious mycelium; annulus single, fibrillose, apical to superior, white, soon evanescent.

Spores subglobose to broadly ellipsoid (8) 9–11  $\times$  7–9  $\mu$ , pale bister in KOH, smooth, with a flattened apex and hence appearing slightly truncate; basidia two- and four-spored, 22–26  $\times$  8–10  $\mu$ , hyaline in KOH; pleurocystidia not differentiated; cheilocystidia basidia-like, pale fuscous in KOH but becoming hyaline, many sporulating basidia seen on the gill edge; gill trama parallel to subparallel, the subhymenium thin and of filamentose hyphae; pileus trama with the cuticle of radially arranged hyphae 5–10  $\mu$  in dia., hyaline in KOH, no clamp connections seen, tramal body hyaline in KOH, of interwoven hyphae 8–12  $\mu$  in dia., hyaline metallic-appearing lactifers numerous.

On exposed soil in an open oak grove after heavy rain, Eastland Texas, Aug. 28, 1938, E. A. Smith.

Observations: The annulus is the same type as that of *Agaricus campestris* but even more fibrillose and evanescent. The species is related to *A. campestris*, but is obviously very distinct both by

virtue of the spore size and very small delicate stature of the carpophores. It can be characterized as one of the smallest species in the genus but having exceptionally large spores. The carpophores are very soft and in wet weather discolor to dark sordid brown soon after maturity much in the same manner that the white form of *A. campestris* discolors. The change is caused by a change in color of the cell sap, and is not caused by the dark spores obscuring the true color.

**Clitocybe Gruberi** sp. nov.

Pileus 8 cm. latus, convexus, siccus, pallide flavidus; lamellae confertae, angustae, decurrentes et reticulatae, pallide flavidae; stipes 3 cm. longus, 2.5 cm. crassus, solidus, intus pallidus, glaber, pallide flavidus, impolitus; sporae  $11-14 \times 4.5-5.5 \mu$ , laevae; cheilocystidia  $38-64 \times 8-10 \mu$ , subventricosa sed elongata. Specimen typicum in Herb. Univ. of Mich. conservatum: Legit prope Juliet, Idaho, May, 1943, Gruber 26.

Pileus 8 cm. broad, broadly convex with an inrolled margin, surface dry and unpolished, evenly pale yellow, "Naples yellow" to "straw yellow" or "primuline yellow" in places where in contact with sticks etc., the margin downy-tomentose and even; flesh thick and firm, white, pallid yellowish when dried, unchanging when cut or bruised, odor radish-like or somewhat sweetish, taste agreeable and mild; lamellae close, about 3 tiers of lamellulae, narrow (material all young), long-decurrent, anastomosing or forming a more or less distinct reticulum on the stipe, concolorous with pileus or paler and duller, edges even; stipe very short, thick and firm, 3 cm. long, 2.5 cm. thick, solid, whitish within, surface concolorous with pileus, glabrous, apex appearing more or less unpolished, base without conspicuously adhering mycelium or rhizomorphs.

Spores white in mass, hyaline or a few with a yellowish tinge when revived in KOH,  $11-14 \times 4.5-5 \mu$ , subcylindric, obtuse at ends, smooth, not amyloid; basidia  $42-48 \times 9-11 \mu$ , clavate with narrow flexuous pedicels, four-spored, pallid and content granulose in KOH; pleurocystidia rare and found mostly very near the gill edge, similar to cheilocystidia; cheilocystidia  $38-46 \times 8-10 \mu$ , slightly ventricose above the middle and then tapered to a long often flexuous forked or variously branched neck, sometimes with a small apical head but apex usually acute, hyaline and thin-walled; gill trama compact, homogeneous, of narrow subparallel hyphae interwoven with contorted lactifers, hyaline in KOH; pileus trama homogeneous, cuticle of interwoven non-gelatinous narrow ( $4-7 \mu$ ) hyphae with golden yellow contents, many hyphal



tips present as pilocystidia, the end cell not differentiated except for a narrow, short proliferation, the cells  $20-35 \times 4-7 \mu$ , proliferation  $10-15 \mu$  long and  $2-4 \mu$  at base, the apex often  $4-6 \mu$  in dia., clamp connections not present.

Singly under conifers, near Juliet, Idaho.

Observations: This is obviously a very robust *Clitocybe* even though the type specimen is not particularly large. It was young and immature when collected, but in spite of this a good spore deposit was obtained. Superficially it resembles a young robust carpophore of *Cantharellus cibarius* in color and in the unpolished appearance of the pileus, but is readily distinguished by its gill characters and spores. In certain respects it resembles carpophores of some of the robust species of *Leucopaxillus*, but its spore characters preclude inclusion in that genus. *Leucopaxillus pulcherrimus* (Peck) S. & S. has similar colors, to judge from descriptions, and the same unpolished surface of the pileus. The long cylindric spores, the color of the carpophore, and the cheilocystidia are an unusual combination of characters in *Clitocybe*.

***Hygrophorus inocybiformis* sp. nov.**

Pileus 3-6 cm. latus, conicus vel obtusus, demum campanulatus vel umbonatus, siccus, fibrillosus vel squamulosus, subumbrinus; lamellae arcuatae vel brevissime decurrentes, latae, subdistantes, pallide cinereae; stipes 3-6 cm. longus, 5-12 mm. crassus, subaequalis, solidus, siccus fusco-fibrillosus, sursum albidus; sporae  $10-13 \times 5-6.5 \mu$ . Specimen typicum in Herb. Univ. of Mich. conservatum: Legit prope Lick Creek Summit, Idaho National Forest, September, 1943, Wm. B. Gruber.

Pileus 3-6 cm. broad, conic to obtuse when young, the margin incurved and fringed with the remnants of a fibrillose veil, expanding to campanulate or obtusely umbonate, sometimes plane or the disc slightly depressed, surface dry and innately fibrillose to fibrillose-squamulose, dark gray ("drab") over all or with drab fibrils over a pallid background in age; flesh whitish or tinged pallid gray near surface, thin except in the disc, soft and fragile, unchanging when cut or bruised, odor none, taste mild; lamellae short-decurrent or arcuate, broad, subdistant, rather thick and firm, waxy, a few forked, pallid to grayish buff ("pale olive-buff"), edges even; stipe 3-6 cm. long, 5-12 mm. thick, subequal, the base at times slightly narrowed, solid, fleshy, white within, surface streaked with dark grayish brown fibrils up to the zone left by the broken veil, dry over all, white and glabrous to appressed silky toward the apex.

Spores white in mass,  $10-13 \times 5-6.5 \mu$ , ellipsoid, smooth, not amyloid; basidia four-spored,  $62-84 \times 10-12 \mu$ ; pleurocystidia and cheilocystidia not differentiated; gill trama of divergent hyaline hyphae  $6-8 \mu$  in dia.; pileus trama with a cuticle of radially arranged nongelatinous hyphae  $10-15 \mu$  in dia., their contents smoky in color and the end-cells more or less pointed, clamp connections abundant; the hyphae of the flesh proper hyaline,  $8-14 \mu$  in dia.

Gregarious to scattered under spruce and balsam fir. It was collected in 1941, A. H. Smith no. 15919 and by Gruber in 1943 in the same region.

Observations: Because of its fibrillose to squamulose pileus this fungus has somewhat the stature and appearance of an *Inocybe* or of a small species of the *Tricholoma terreum* group. Actually, the fungus is closely related to *H. pustulatus*, but is readily distinguished by its spores and by the fibrillose veil. *H. pustulatus* was found in the same area in 1943 and appeared to have a perfectly dry stipe. Previously (Smith, 1937) reported a collection from California with a thin gelatinous universal veil. The latter was found during very wet weather, whereas the Idaho collection was made during dry weather. Since large numbers of carpophores were not available for study in either instance, the discrepancy is merely pointed out here in the hope that any who find *H. pustulatus* will pay particular attention to the presence or absence of a gelatinous veil. *H. olivaceo-alubus* has both a glutinous sheath and one of fuscous fibrils beneath it. Consequently, *H. inocybeformis* might be considered closely related to it.

***Hypholoma dispersum* var. *idahoense* var. nov.**

Pileus 1-2.5 cm. latus, conicus vel campanulatus demum convexus vel umbonatus, glaber, ad marginem appendiculatus, obscure fulvus demum sordide ochraceus; sapor acerbus; lamellae confertae, adantae, angustae, albiae demum obscurae; stipes 6-8 cm. longus, 1-2 mm. crassus, aequalis, deorsum obscurus, sursum albidus demum sordidus, fibrillosus; sporae  $7-8.4 \times 3.5-4 \mu$ . Specimen typicum in Herb. Univ. of Mich. conservatum: Legit prope Lake Fork Ranger Station, Idaho National Forest, Idaho, Oct., 1943, Wm. B. Gruber P-81.

Pileus 1-2.5 cm. broad, obtusely conic with an incurved margin, becoming campanulate to broadly convex with a small conic umbo, surface moist and glabrous except for the appendiculate margin, veil remnants adhering to margin as a thin submem-

branous band or band broken up into patches, subhygrophanous, dull tawny to cinnamon-brown on the disc, paler toward the margin, fading around the disc first to sordid ochraceous; flesh thin, pallid, odor not distinctive, taste distinctly bitter and leaving a persistent after taste (in fresh material); lamellae close, ascending adante, narrow to moderately broad, white or whitish, becoming sordid grayish brown, edges white floccose; stipe 6-8 cm. long, 1-2 mm. thick, equal, cartilaginous, sordid brown to bister below and gradually darkening upward, at first covered by a conspicuous coating of white fibrils causing it to appear white or silvery, apex whitish beneath the fibrils but eventually becoming brownish, base conspicuously strigose with white to tawny hairs or mycelium.

Spores  $7-8.5 \times 3.5-4 \mu$ , ellipsoid, apex truncate, dull tawny brown in KOH; basidia  $22-26 \times 5-6 \mu$ , four-spored; pleurocystidia abundant, mucronate,  $26-34 \times 8-10 \mu$ , with a highly refractive irregular amorphous mass or body in central portion; cheilocystidia cylindric to subventricose,  $30-36 \times 4-6 \mu$ , apices rounded, hyaline, content homogeneous; gill trama parallel, hyaline or nearly so; pileus trama with a thin subgelatinous pellicle of hyaline more or less radially arranged hyphae  $3-5 \mu$  in dia. and bearing clamp connections, beneath this a hypoderm of radially arranged hyphae  $8-12 \mu$  in dia. which are dark yellowish in KOH, the remainder of the trama paler and not compactly interwoven.

Cespitose to subcespitose on conifer logs, Lake Fork Ranger Station, Idaho National Forest, Idaho, Oct., 1943, Wm. B. Gruber *P-81*.

Observations: This variety differs from var. *typicum* in its slender cheilocystidia, cespitose habit, paler colors of the young gills and apex of the stipe, and by the very bitter taste. It was found during a dry season during which very few agarics fruited, but was found in quantity in the one locality.

***Hypholoma olympianum* sp. nov.**

Pileus 2.5-4 (6) cm. latus, obtusus demum planus vel umbonatus, canescens, glabrescens, pallide alutaceus; sapor amarus; lamellae confertae, adnatae sed secedenti-liberae, pallide luteae; stipes radicans, 5-7 cm. longus, 3-6 cm. crassus, sursum luteus, deorsum sordide ferrugineus; sporae  $6-7.5 \times 4-4.5 \mu$ , obscure ferrugineae. Specimen typicum in Herb. Univ. of Mich. conservatum: Legit prope Storm King Mountain, Olympic National Park, Wash., Oct. 16, 1941, A. H. Smith 18,003.

Pileus 2.5-4 (6) cm. broad, obtuse to convex and with an incurved margin at first, expanding to plane or retaining a slight obtuse umbo, surface at first canescent from a thin coating of whitish silky fibrils but soon glabrescent or fibrils more or less persistent toward the margin, moist, "cinnamon buff" to "clay-color" on disc and paler yellow toward the margin (sordid honey color to alutaceous); flesh hard and thick in the disc, abruptly thinner toward the margin ( $\pm 3$  mm. at the stipe), pallid but soon lutescent where cut or broken, odor not distinctive, taste quickly and decidedly bitter; lamellae close,  $\pm 33$  reach the stipe, 3-4 tiers of lamellulae, narrow (3-4.5 mm.), bluntly adnate but seceding, "cream-buff" (very pale yellowish) young, "buckthorn brown" in age (dark sordid yellowish brown) and often with dark rusty spots, edges even and pale yellowish; stipe 5-7 cm. long, 3-6 mm. thick, subfusoid to equal above a long tapered pseudorhiza, tubular to hollow, surface densely white-fibrillose from veil remnants, apex yellowish and pruinose, becoming yellowish where handled and finally dark sordid brown, more or less glabrescent.

Spores dull cinnamon brown in mass, when revived in KOH very pale dull brown, ellipsoid to ovoid, smooth, apical pore not evident under ordinary magnifications,  $6-7.5 \times 4-4.5 \mu$ ; basidia four-spored,  $18-22 \times 5-6 \mu$ , projecting somewhat when sporulating; pleurocystidia abundant,  $22-36 \times 9-14 \mu$ , ventricose and mucronate, with an irregular highly refractive mass in the enlarged portion; cheilocystidia abundant,  $18-28 \times 4-8 \mu$ , subclavate to subventricose, the apices rounded; gill trama subregular, homogeneous; pileus trama with a very thin pellicle of narrow ( $1.5-2.5 \mu$ ) hyaline, subgelatinous (when revived in KOH) hyphae, beneath this a region of brownish compactly arranged larger hyphae of about the same diameter as those making up the trama, clamp connections present.

Gregarious to scattered around Douglas fir stumps, Storm King Mountain, Olympic National Park, Washington.

Observations: *H. olympianum* is very similar to *H. radicosum* Lange but there is a distinct difference in the color of the spores when both are compared under the microscope. Those of *H. radicosum* are distinctly darker in color. There is a second distinct difference in the color of the fibrils over the basal portion of the stipe. In *H. radicosum* dark tawny fibrils cover the lower portion and often become arranged in patches. These are not present in *H. olympianum*. In the latter species, the change in color on the bruised portions of the stipe may be significant, but

this needs to be verified by many observations since other species in the genus show this character at times and it does not appear significant.

***Hypholoma subochraceum* sp. nov.**

Pileus 2-4 cm. latus, convexus, glaber, glutinosus vel viscidus, subochraceus; lamellae confertae, angustae, pallide luteae demum sordide cinnamomeae; stipes 5-9 cm. longus, 5-7 mm. crassus, aequalis, sursum luteo-albus, deorsum fusco-ferrugineus; sporae  $5-6 \times 2.5-3 \mu$ .—Specimen typicum in Herb. Univ. of Mich. conservatum: Legit prope Mt. Angeles, Olympic Mountains, Wash., Oct. 4, 1941, A. H. Smith 17,526.

Pileus 2-4 cm. broad, convex with an inrolled margin and becoming broadly convex to plane, surface glabrous except for scattered fibrillose flecs along the margin from the broken veil, glutinous (slimy as in *Lactarius mucidus*) when wet, under a lens appearing somewhat appressed fibrillose beneath the gluten, very pale ochraceous tawny on the disc, "massicot yellow" (pale clear yellow) near the margin, when young more or less "cinnamon-buff" (pallid alutaceous) over all; flesh thin, firm, equal, yellowish, unchanging, odor none, taste mild; lamellae close,  $\pm 35$  reach the stipe, 2 tiers of lamellulae, equal and narrow in young caps, adnate becoming depressed-adnate, pale yellow ("margeurite yellow") young, becoming tinged sordid cinnamon-brown at maturity, edges even; stipe 5-9 cm. long, 5-7 mm. thick at apex, equal or slightly enlarged downward, tubular to hollow, surface over lower portion pale yellowish white from a thin coating of white fibrils which extends up to the evanescent zone left by the broken veil, yellowish beneath the fibrils (concolorous with the gills), apex yellow and silky, soon becoming sordid rusty brown from the base upward and glabrescent.

Spores dull snuff brown in mass, very pale brown under the microscope, smooth,  $5-6 \times 2.5-3 \mu$ , ellipsoid to narrowly ellipsoid, apical pore not visible under ordinary magnifications; basidia four-spored,  $16-18 \times 4-5 \mu$ , projecting only slightly when sporulating; pleurocystidia very abundant, ventricose-mucronate,  $32-46 \times 10-14 \mu$ , with a highly refractive irregular body or bodies in the enlarged portion when revived in KOH; cheilocystidia similar to pleurocystidia and abundant; gill trama subregular and brownish when revived in KOH; pileus trama homogeneous beneath a thick ( $75-150 \mu$ ) gelatinous pellicle of narrow ( $2-4 \mu$ ) yellow hyphae, clamp connections present.

Cespitose on conifer logs, Mt. Angeles, Olympic Mountains, Wash.

Observations: The distinctive features of this species are the very slimy pileus when wet, the small spores and yellow gills. The spores are very pale and not truly purple brown in mass, but they are thick-walled and have a small apical pore and hence are typical in structure if not in color. The cystidia of course are typical of *Hypholoma*. *H. tsugaecola* is close but has larger spores and lacks cystidia with the characteristic highly refractive content. Its spores are also different, being typical for the genus in color. *H. incomptum* Massee, is also described as being viscid but should differ markedly in spore size ( $8 \times 3.5 \mu$ ) as well as in the yellow scales on the stipe and in the color of the pileus.

***Melanoleuca eccentrica* sp. nov.**

Pileus 4–6.5 cm. latus, umbonatus vel subplanus, glaber, pallide alutaceus; odor et sapor subspermaticus; lamellae confertae, angustae, pallidae; stipes eccentricus, 4–5 cm. longus, 9–10 mm. crassus, solidus, subavellaneus, glaber; sporae  $7-8 \times 4-5 \mu$ . Specimen typicum in Herb. Univ. of Mich. conservatum: Legit prope Olympic Hot Springs, Olympic National Park, Wash., Oct. 8, 1941, A. H. Smith 17,667.

Pileus 4–6.5 cm. broad, obtusely umbonate with an inrolled margin, expanding to nearly plane, margin cottony when young, surface glabrous, moist and opaque, "warm buff" over all when young (pale buff to alutaceous), becoming paler and more yellowish ("cartridge buff") along the margin, finally nearly "cinnamon buff" on the disc; flesh thick, 1 cm. in the umbo, abruptly thinner ( $\pm 5$  mm.) toward the stipe, pallid ("tilleul buff"), very firm, unchanging when bruised, odor when cut subspermatic as in many species of *Inocybe*, taste similar and very disagreeable; lamellae crowded, shallowly adnexed, narrow (3–4 mm.), equal, pallid, edges uneven; stipe eccentric, 4–5 cm. long, 9–10 mm. thick, equal or enlarged below, stuffed solid, interior pallid, surface darker and more or less avellaneous, appressed fibrillose-striate, glabrous.

Spores  $7-8 \times 4-5 \mu$ , ellipsoid, covered with minute strongly amyloid warts; basidia four-spored,  $34-40 \times 7-8 \mu$ ; pleuro- and cheilocystidia not differentiated; gill trama not amyloid, regular to subregular, cells 5–10  $\mu$  in dia. and cylindric, the length very variable; pileus trama with a pellicle of interwoven narrow (3–6  $\mu$ ) hyphae, the remainder floccose and loosely interwoven, clamp connections not present.

Gregarious under conifers, Olympic Hot Springs, Olympic National Park, Wash., Oct. 8, 1941 (16,667).

Observations: The pale yellowish brown color, the taste and the eccentric stipe along with the pallid gills are distinctive. The spores apparently are white in mass, but the only deposit obtained was thin. The lack of cheilocystidia is also characteristic but is a more difficult character to use since very careful observations must be made. *M. praecox* Murr., *M. mirabilis* (Bres.) Singer, *M. dehiscens* (Kalchbr.) Singer and *M. angelesiana* are other species in which the cheilocystidia are lacking.

***Melanoleuca angelesiana* sp. nov.**

Pileus 5–7 cm. latus, umbonatus vel planus, glaber, subviscidus olivaceofuscus; lamellae confertae, latae, cinerae mox albidae, demum fusco-maculatae; stipes 5–6 cm. longus, 10–12 mm. crassus, olivaceofuscus, glaber; sporae 7–8 (9)  $\times$  4.5–5 (6)  $\mu$ ; cheilocystidia nulla.—Specimen typicum in Herb. Univ. of Mich. conservatum: Legit prope Lake Angeles, Olympic Mts., Wash., June 25, 1939, A. H. Smith 14,633.

Pileus 5–7 cm. broad, at first with a low obtuse umbo and an inrolled margin, becoming plane or the margin uplifted, glabrous, subviscid to the touch but lacking a gelatinous separable pellicle, opaque when moist, color fuscous to "buffy brown" (dull olive-brown), margin paler grayish brown ("hair-brown"); flesh 2–3 mm. thick at the stipe, tapered to the margin, watery gray when moist, pallid when faded, odor none, taste mild; lamellae crowded,  $\pm$  75 reach the stipe,  $\pm$  3 tiers of lamellulae, moderately broad (5–7 mm.), narrowed toward the margin, horizontally adnate to slightly adnexed, pale ashy gray becoming pallid or white, the edges even and staining sordid brownish where bruised; stipe 5–6 cm. long, 10–12 mm. thick near the apex, flared slightly at the base and apex, surface concolorous with the pileus or paler, longitudinally fibrous striate, glabrous or with scattered fibrils caused by the shredding of the cuticle, hollow and sordid watery gray within.

Spores 7–8 (9)  $\times$  4.5–5 (6)  $\mu$ , ellipsoid, covered with strongly amyloid minute warts, with a subhilar depression; basidia four-spored; pleuro- and cheilocystidia not found; gill trama interwoven, not amyloid; pileus trama homogeneous beneath a surface layer of more or less interwoven to subradial hyphae with dark brown contents and not narrower than the hyphae of the trama proper.

Singly along the trail at Lake Angeles, Olympics, Wash., June 25, 1939, A. H. Smith 14,633.

Observations: This species is characterized by the grayish gills which become white in age and stain brownish if bruised, by the lack of cheilocystidia, and lack of any distinctive odor or taste. Unfortunately a spore print was not obtained. *Melano-leuca praecox* Murr. also lacks cheilocystidia, but no mention is made of its gills staining sordid brownish and their color is given as "avellaneous with a murinous tint." This should indicate that its gills and pileus are practically the same color. Such is not the case in *M. angelesiana*.

***Pholiota carbonaria* sp. nov.**

Pileus (1) 2-4 (5) cm. latus, convexus vel planus, viscidus, ferrugineo-squamulosus dein subglaber, luteus dein subfulvus; lamellae confertae, adnatae, angustae, pallidae dein subfulvae; stipes 3-6 cm. longus, 3-6 mm. crassus, squamosus, sordide luteus, squamis cinnabarinis; sporae  $5-6.5 \times 4-5.5 \mu$ ; pleurocystidia  $46-63 \times 9-16 \mu$ , fusoid ventricosa.—Specimen typicum in Herb. Univ. of Mich. conservatum: Legit prope Crescent City, Calif., Dec. 7, 1937, A. H. Smith 9500.

Pileus (1) 2-4 (5) cm. broad, broadly convex, becoming plane or slightly umbonate, sometimes the disc slightly depressed in age, surface with a separable viscid pellicle and at first covered by concentric rows of small "hazel" to "ferruginous" fibrillose scales (scales very bright fiery red) on a "warm buff" to "antimony-yellow" (pale yellow) background, ground color gradually changing to nearly "cinnamon-brown" (rather dark brown) in age and the scales becoming a duller reddish brown; flesh watery brown, thick in the disc, tapering slightly toward the margin, odor and taste not distinctive; lamellae crowded, bluntly adnate, narrow, equal, white when young, sometimes grayish (not yellow), becoming nearly "snuff-brown" (dull yellowish brown) at maturity, edges slightly crenulate; stipe 3-6 cm. long, 3-6 mm. thick, equal, compressed or terete, flesh sordid watery yellow, solid below but tubular above, surface covered to near the apex by small "hazel" or "ferruginous" recurved fibrillose scales, ground color sordid yellowish, the apex yellowish and merely pruinose.

Spores  $5-6.5 \times 4-4.5 \mu$ , ellipsoid to subovoid, not truncate, smooth, nearly cinnamon-brown when revived in KOH; basidia four-spored; pleurocystidia very abundant,  $46-63 \times 9-16 \mu$ , fusoid ventricose, subacute, smooth or with a resinous encrustation over the apex; cheilocystidia  $24-32 \times 8-12 \mu$ , subsaccate to subfusoid, obtuse, hyaline; gill trama with a central strand of regularly arranged floccose hyphae, the subhymenium gelatinous



(when revived in KOH); pileus trama homogeneous beneath a thick gelatinous pellicle.

Cespitose to densely gregarious on burned soil and charred wood, Lake Tahkenitch, Ore., Nov. 10, 1935 (3406); Nov. 11 (3418); Booth, Ore., Nov. 24 (3616); Trinidad, Calif., Nov. 27, 1935 (3638); Orick, Calif., Dec. 4 (3773); Crescent City, Nov. 22, 1937 (9003); Dec. 3 (9342); Orick, Calif., Dec. 4 (9386); Trinidad, Dec. 6 (9446); Crescent City, Calif., Dec. 7 (9500-type); Olympic Hot Springs, Olympic National Park, Wash., Oct. 17, 1941 (17,998); Oct. 17 (18,010). Kauffman collected it at Lake Quinault, Wash., in 1925 and tentatively identified it as *Pholiota terrestris* Overholts.

Observations: *P. carbonaria* is closely related to *P. terrestris* but differs in its habitat, the color of the universal veil, and the size of the cystidia. *P. cruentata* Cooke & Smith should differ in having yellow gills at first and rubescent flesh. It is said to occur on burned areas also. *P. tuberculosa* sensu Bresadola has spores  $7-9 \times 4-5 \mu$  and yellow gills, but is illustrated as having brightly colored scales somewhat like those of *P. carbonicola*. *P. carbonicola* was most abundant during the cold season of 1935, and fruited most abundantly after a hard freeze.

#### ***Pholiota Kauffmaniana* sp. nov.**

*Pholiota flammans* similis sed sapor mitis et pileus viscidus. Specimen typicum in Herb. Univ. of Mich. conservatum: Legit prope Anderson Creek, Baker National Forest, Wash., Sept. 1, 1941, A. H. Smith 16, 268.

Pileus (3) 4-8 (10) cm. broad, obtusely conic with an incurved sterile margin when young, becoming obtusely campanulate or plane with a low umbo, umbo sometimes obsolete, viscid to glutinous beneath a surface-covering of recurved fibrillose scales, somewhat glabrescent at least over the umbo or disc, margin decorated with submembranous patches of veil tissue, color "picric yellow" to "lemon-chrome" (very brilliant pale yellow) over all including the scales, becoming "amber-yellow" to "raw sienna" at least on the disc (bright yellowish tawny); flesh rather thick and firm, "picric-yellow" throughout or with a watery greenish yellow band next to the gills, odor and taste perfectly mild; lamellae "picric-yellow" but staining sordid brown along the edges when bruised, sharply adnexed, close to crowded, 3 tiers of lamellulae, moderately broad (up to  $\pm 5$  mm.), edges

even; stipe 4-9 cm. long, 5-8 (10) mm. thick, equal or nearly so, bright picric-yellow both inside and out, increasingly scaly upward with recurved fibrillose picric-yellow scales; annulus merely a superior zone of bright yellow fibrils or submembranous but evanescent; surface of stipe appressed fibrillose above annulus.

Spores ellipsoid, smooth, very minute,  $4-5 \times 2-2.5 \mu$ , very pale under the microscope, rusty in mass; basidia four-spored; pleuro- and cheilocystidia similar and abundant,  $22-30 \times 7-9 \mu$ , obtuse, subcylindric to submucronate or broadly fusoid-ventricose, content usually homogeneous, and yellow or brownish, sometimes hyaline and some with a highly refractive amorphous content, projecting slightly beyond the hymenium; gill trama regular except for the narrow subgelatinous interwoven subhymenium; pileus trama homogeneous beneath a thick gelatinous pellicle; numerous bundles of long needle-like crystals forming in or on the hymenium and trama of pileus and gills when revived in KOH.

Single to cespitose on conifer logs and debris, Grassy Patch, Great Smoky Mts. National Park, Tenn., Sept. 3, 1938 (10,868); Shuksan Inn, Wash., Aug. 15, 1941 (16,161), Aug. 14 (16,186); Anderson Creek, Baker National Forest, Aug. 19 (16,268); Timberline Camp, Mt. Baker, Wash., Aug. 24 (16,339); Baker Lake, Wash., Sept. 1, (16,549); Mt. Angeles, Olympic Mts., Wash., Sept. 26, 1941 (17,342). Kauffman made four collections at Lake Quinault, Wash., in 1925.

Observations: Kauffman recognized this fungus as a new species closely related to *P. flammans* (Fries) Quél. but differing particularly in its viscid pileus. The literature of *P. flammans* from the time of Fries down to the present is consistent in describing it as dry. Recent works such as those of Métrod (1938) and Lange (1938) also bear out this concept. Métrod in particular has given sufficient information on the European fungus to enable one to make a critical comparison with the species described here. Two characters stand out as sharply distinct, namely the viscid pileus and mild taste of *P. Kauffmaniana*. *Pholiota lucifer* differs from both of these in having larger spores. Although Overholts (1927) adhered to the tradition that *P. flammans* has a dry pileus, he referred to one collection at New York in which the collectors notes described the pileus as viscid.

The viscosity of the pileus can be demonstrated almost as

readily from dried as from fresh material. The pellicle of a viscid species gelatinizes appreciably and has a very characteristic appearance in either water-mounts of fresh material or in mounts of dried material revived in KOH. In Kauffman's collections from the Adirondack Mountains of New York, in one collection he made in Sweden, in his Colorado specimens, and in all of my collections from the Adirondacks, Nova Scotia, Ontario and Tennessee the pilei possess the thick gelatinous pellicle characteristic of a viscid species. The taste of these collections was not recorded, and they were all identified as *P. flammans*. Since the hyphae of the pellicle are very narrow ( $2.5-4\ \mu$ ) and form a rather sharply differentiated layer between the scales on the surface and the main portion of the tramal body, it is doubtful if Métrod would have overlooked them in his study. Consequently, on the basis of Kauffman's collection from Sweden, it appears that *P. Kauffmaniana* occurs there as well as throughout the United States. The bundles of needle-like crystals which form in mounts of *P. Kauffmaniana* revived in KOH may be an additional distinguishing character.

***Tricholoma atroviolaceum* sp. nov.**

Pileus 5-12 (14) cm. latus, obtusus vel umbonatus, siccus, atro-violaceus et squamulosus; odor et sapor farinaceus; lamellae confertae, sinuatae, latae, fumoso-avellaneae; stipes 6-14 cm. longus, 10-30 mm. crassus, solidus, subcinereus mox umbrinus, fibrillosus demum furfuraceus; sporae  $7-9 \times 3.5-6\ \mu$ . Specimen typicum in Herb. Univ. of Mich. conservatum: Legit A. H. Smith 8195 prope Kerby, Ore., Nov. 29, 1937.

Pileus 5-12 (14) cm. broad, obtuse and with a slightly incurved margin when young, becoming broadly umbonate or plane, the margin spreading or recurved somewhat in age and frequently plicate or splitting radially, surface dry and covered over all except the margin by minute recurved blackish violet scales, color blackish violet from the dense covering of fibrils ("dark grayish brown" over central part and "benzo brown" along the margin, darker in age); flesh thin but rigid and brittle (4-5 mm. near the stipe), sordid brownish gray to nearly "drab-gray," odor very strongly farinaceous, taste slightly to strongly farinaceous, no color change when cut or bruised but sometimes gradually darkening; lamellae close, 1-2 tiers of lamellulae, sinuate to adnexed, broad (up to 1 cm.  $\pm$ ), very brittle, "light cinnamon-drab," "light drab" or "wood-brown" (dull cinnamon overcast

with gray), edges uneven to eroded and usually staining blackish; stipe 6–14 cm. long, 10–30 mm. thick, equal to enlarged above or sometimes with an abruptly bulbous base, solid, tinged pale drab within, pallid at very first but soon tinged “benzo brown” and finally quite dark, surface appressed fibrillose and becoming somewhat furfuraceous at times from the broken cuticle (color darker when the fibrillose coating is dense).

Spores subellipsoid to subovoid,  $7-9 \times 4.5-6 \mu$ , not amyloid; basidia four-spored; pleuro- and cheilocystidia not differentiated; gill trama subregular, not or only very slightly amyloid; pileus trama pallid and homogeneous beneath a surface layer distinctly differentiated by the dark fuscous brown color of the cells, the pigment located on the wall as a very thin incrustation.

Gregarious under conifers, Oregon-California state line near Kerby, Ore., Nov. 29, 1937 (8195-type); scattered under conifers, Olympic Hot Springs, Olympic Mts., Wash., Oct. 2, 1941 (17,539), same locality Oct. 8 (17,701), Oct. 11 (17,764), Oct. 15 (17,906); Storm King Mountain, Olympic National Park, Oct. 16, 1941 (17,971); Mt. Angeles, Olympic Mountains, Wash., Oct. 20, 1941 (18,063).

Observations: *Tricholoma hordum* Fries *sensu* Ricken is described as having an almost violet-black pileus, but lacks a farinaceous odor and taste, has distinctly smaller spores, and apparently a paler stipe. Fries described *A. hordus* as cinereous as well as lacking a distinctive odor and taste, so my collections cannot be placed there. *Tricholoma elytroides* is also close but should be readily distinguished by its smaller spores and paler pilei. *T. pardinum sensu* Konrad and Maublanc is also close but readily distinct by its paler color. The lack of cheilocystidia distinguished *T. atrovioleaceum* from such fungi as *T. atosquamosum* and *T. squarrulosum*. *T. murinaceum sensu* Bresadola has a bitter then acrid taste, and apparently much paler colors.

***Tricholoma aurantio-olivaceum* sp. nov.**

Pileus 1–3.5 cm. latus, conico-campanulatus, siccus, aurantio-fibrillosus demum obscure aurantius; lamellae confertae, latae, adnexae, ventricosae, pallidae, aurantio-maculatae dein olivaceo-cinereae; stipes 4–6 cm. longus, 3–5 mm. crassus, deorsum attenuatus, aurantio-fibrillosus, sursum aurantio-guttatus; spores  $5.5-7 \times 3.5-4.5 \mu$ .—Specimen typicum in Herb. Univ. of Mich. conservatum: Legit prope Olympic Hot Springs, Olympic National Park, Wash., Oct. 8, 1941, A. H. Smith 17,666.

Pileus 1–3.5 cm. broad, obtusely conic with an incurved margin, expanding to conic-campanulate or obtusely umbonate and with a spreading margin, surface dry and appressed fibrillose, young specimens with bright orange ("ochraceous orange") fibrils on a "cinnamon-buff" (buff) background, in age either yellowish over all or developing an avellaneous or sordid yellow-brown ("snuff-brown") cast, the colors becoming sordid in age; flesh thin except in the umbo (1.5–2.5 mm.), pallid, odor none, taste mild, unchanging when cut; lamellae close, 40–60 reach the stipe, 1–2 tiers of lamellulae, broadly and deeply adnexed, broad (5–6 mm.), ventricose near the stipe and tapered to the margin, white or "tilleul buff" (pallid) when young, gradually becoming pale cream-color and soon stained with pale orange-brown spots which darken to dark olivaceous, edges uneven but not eroded; stipe 4–6 cm. long, 3–5 mm. thick at the apex, narrowed downward to an almost pointed base, solid or with a stuffed tubule, surface covered with a thin coating of bright orange ("ochraceous orange") fibrils and the apex beaded with "ochraceous orange" droplets, the orange fibrils becoming sordid brownish in age, apex whitish, base soon stained orange-brown and finally olivaceous brown, the change gradually progressing upward.

Spores  $5.5\text{--}7 \times 3.5\text{--}4.5 \mu$ , ellipsoid, smooth, not amyloid; basidia four-spored; pleurocystidia and cheilocystidia not differentiated; gill trama regular to subregular, not amyloid, cells  $7\text{--}12 \mu$  in dia. and cylindric,  $20\text{--}100 \mu$  long; pileus trama homogeneous, not amyloid, surface-hyphae with orange walls.

Densely gregarious under conifers, Olympic Hot Springs, Olympic National Park, Wash., Oct. 8, 1941 (17,666) and again Oct. 15 (17,901); Lake Mills, Olympic Mountains, Wash., Oct. 15, 1941 (17,951).

Observations: Kalchbrenner (1873) described *Agaricus psam-mopus* as having bright yellow gills and an acrid taste but did not mention a change in color of the gills when bruised or in age. Although Kalchbrenner's species is included in practically all the manuals of the European agaric flora, nowhere is it described as slender or with gills that stain olivaceous gray. Its stipe is usually described as 6–10 (18) mm. thick. Since weather conditions were very favorable for agarics around Olympic Hot Springs in the fall of 1941, the slender stature and small size of the carpophores collected there cannot be explained as being caused by unfavorable fruiting conditions. There is no larch in the region

where my collections were made. The only conifer common to all the localities was Douglas fir. In addition to habitat, color-change, and small size, there may be other significant differences between *T. psammopodium* and *T. aurantio-olivaceum*. The stipes in my collections were evenly fibrillose. The drops of fluid near the apex may leave slight stains in drying but do not cause the apex to appear granular. *T. psammopodium* was reported for the United States by Rea and Ramsbottom (1929). American mycologists have probably considered it as merely a form of *T. vaccinum*.

***Tricholoma rhizoideum* sp. nov.**

Pileus 1–3 cm. latus, convexus, siccus, subfibrillosus, pallide avellaneus; lamellae adnatae vel subdecurrentes, angustae, subdistantes, pallide subincarnatae; stipes 3–5 cm. longus, 3–5 mm. crassus, deorsum attenuatus, intus subavellaneus, extus albido-fibrillosus, sursum furfuraceus; sporae  $4-5 \times 2-3 \mu$ . —Specimen typicum legit A. H. Smith 18,107, prope McKenzie Pass, Ore., Oct. 29, 1941; in Herb. Univ. of Mich. conservatum.

Pileus 1–3 (4) cm. broad, broadly convex with an inrolled margin, becoming plane, surface dry and satiny from a thin white fibrillose coating, color evenly "pale vinaceous fawn" (very pale avellaneous), darker and more sordid vinaceous buff when surface fibrils have worn away; flesh thin but firm (1.5–2 mm.), equal; lamellae close to subdistant (32–36 reach the stipe, 1–2 tiers of lamellulae) "pale pinkish buff" to "pale pinkish cinnamon" or darker in age (pale buff or tinged flesh-color and in age sordid pale alutaceous); stipe 3–5 cm. long, 3–5 mm. thick at apex, narrowed below to a long flexuous pallid vinaceous rhizomorph, solid, flesh pallid vinaceous buff, surface white from a dense coating of white fibrils which cause apex to be more or less furfuraceous, glabrescent, a pallid sordid brownish color below, rhizomorphs and young individuals growing in dense masses throughout the soil but no sclerotia found.

Spores  $4-5 \times 2.5-3 \mu$ , ellipsoid, smooth, not amyloid; basidia four-spored; pleuro- and cheilocystidia not differentiated; gill trama of narrow interwoven hyphae, not amyloid; pileus trama homogeneous, not amyloid, surface hyphae interwoven, clamp connections present but rare.

Cespitose to subcespitose in the duff under conifers, possibly on the very decayed remains of an old fungus but evidence not positive. McKenzie Pass, Ore., Oct. 29, 1941 (18,107) and from Mt. Shasta, California, Wm. B. Cooke.

Observations: This species is very closely related to *Tricholoma sclerotoideum* Morse but readily distinguished by its small spores and lack of fleshy sclerotoid masses at the base of the stipe. At first I thought *T. rhizoideum* might be a gigantic form of *Collybia cirrhata*, but the more distant gills appear distinct along with other secondary characters such as size and gill-color. However, it appears that a rather distinct phylogenetic series of species exists here. *Collybia tuberosa*, *C. cirrhata*, *C. Cookei*, *C. racemosa* and *C. olympiana* though smaller are similar in general aspect to *T. sclerotoideum* and *T. rhizoideum*.

***Tricholoma subumbrinum* sp. nov.**

Pileus 3-6 cm. latus, obtusus vel subumbonatus, viscidus, virgatus, disco sordide luteo-umbrinus, demum fuligineo-maculatus; odor et sapor valde farinaceus; lamellae subsinuatae, confertae, latae, pallidae demum umbrino-maculatae; stipes 9-12 cm. longus, 9-12 mm. crassus, pallidus, glaber vel subsquamulosus; spores  $7-8.5 \times 4-5 \mu$ .—Specimen typicum in Herb. Univ. of Mich. conservatum: Legit prope Olympic Hot Springs, Olympic National Park, Wash., Oct. 8, 1941, A. H. Smith 17,671.

Pileus 3-6 cm. broad, obtusely conic to subconvex, the margin inrolled at first, becoming plane or retaining a low subconic umbo, surface viscid but soon dry, pellicle not separable, glabrous or appearing streaked as if with appressed fibrils, the ground color "tilleul buff" (pallid) and most evident toward the margin, central portion "Saccardo's umber" or "sepia" (sordid yellowish brown), in age spotted "mummy brown" or finally nearly "drab" on the umbo; flesh thick and firm, tapering evenly to the margin, brittle, pallid to pale avellaneous, odor and taste very strongly farinaceous; lamellae close, subsinuate to adnexed, broad (5-8 mm.), becoming subventricose, white or pallid, edges usually staining sordid brown where injured and becoming sordid brownish spotted in age; stipe 9-12 cm. long, 9-12 mm. thick at apex, evenly enlarged to the base, soon hollow, pallid both inside and out, apex minutely fibrillose-furfuraceous, remainder glabrous or appressed fibrillose, slightly scaly in age and scales with a tendency to become sordid brownish.

Spores  $7-8.5 \times 4-5 \mu$  smooth, ellipsoid, not amyloid; basidia four-spored,  $30-36 \times 7-8 \mu$ ; cheilocystidia and pleurocystidia not differentiated; gill trama of entangled more or less regularly arranged cells, not amyloid; pileus trama homogeneous beneath a thin gelatinous pellicle the narrow hyphae of which have sordid yellowish brown contents, remainder of tissue hyaline, not amyloid.

Scattered under conifers, Olympic Hot Springs, Olympic National Park, Wash., Oct. 8, 1941 (17,671-type) and (17,690), same locality Oct. 17, 1941 (18,917).

Observations: In collection 18,917 the older pilei were more or less fibrillose scaly. The species is very similar to *T. portentosum* but differs in its sordid yellowish brown color, slightly larger spores and the sordid brownish stains on the cap and gills. *T. subumbrinum* is not related to the reddish brown species with changing flesh and gills. *T. spermaticum sensu* Lange appears close to *T. subumbrinum* but its gills are not spotted and the colors as described and figured are too pale. *T. spermaticum* is generally considered to be a white fungus.

***Tricholoma ionides* var. *farinaceum* var. nov.**

Sapor farinaceus; pileus demum vinaceo-lilacinus; sporae  $4-5 \times 2-3 \mu$ . Specimen typicum in Herb. Univ. of Mich. conservatum: Legit Mrs. W. H. Burt et A. H. Smith 18,339, prope Ann Arbor, Mich., June 13, 1942.

Pileus 2-5 (7) cm. broad, broadly convex young, soon expanded plane or the margin recurved and wavy, surface moist and glabrous at first, dull violaceous gray ("light benzo brown") on disc and nearly drab on the margin, fading as if subhygrophanous and then appearing unpolished or very finely silky, the colors changing to dull lilac over all ("purple-drab," "light vinaceous drab," "light vinaceous purple," "vinaceous lilac," "slate-violet" to "deep slate-violet"), sometimes becoming bright lilac-vinaceous; flesh whitish or flushed lilac near the cuticle, brittle, thin, odor and taste distinctly farinaceous; lamellae crowded, narrow ( $\pm 2$  mm.) but finally becoming moderately broad, adnate or slightly emarginate with decurrent lines on the stipe, white but in age becoming slightly cream colored, edges soon becoming uneven or minutely eroded; stipe 3-5 cm. long, 3-7 (9) mm. thick, equal, hollow, elastic, surface thinly appressed fibrillose and more or less concolorous with the pileus, white strigose to mycelioid at base, rind cartilaginous to subcartilaginous.

Spores  $4-5 \times 2-3 \mu$ , ellipsoid to ovoid, smooth, not amyloid, white in mass; basidia four-spored,  $14-16 \times 4-5 \mu$ ; cheilocystidia and pleurocystidia not differentiated; gill trama subparallel, the cells long and broad ( $50 \times 6-10 \mu$ ); pileus trama homogeneous, the hyphae on the surface interwoven and with a dull lilac content, clamp connections not found.

Gregarious or single on soil in low grassy oak woods or along the borders of swamps, Cavanaugh Lake, Chelsea, Mich., Aug. 1,



1915, Kauffman; Whitmore Lake, Mich., July 11, 1929, A. H. Smith (notes by Kauffman), under elm, on muck at the edge of a bog; Howell, Mich., July 1, 1935, Smith 1446; Burt's woods, Ann Arbor, Mich., under oak, June 13, 1942, Mrs. W. H. Burt and A. H. Smith 18,339-type.

Observations: The sharpest distinction between typical material and the variety is the pronounced farinaceous taste of the latter, but there are other differences which appear to be more significant. The colors of the pilei are quite similar, but in the typical variety those of old pilei tend toward sordid grayish whereas in var. *farinaceum* they become brighter in age. Very old specimens have been examined and the gills never were found to be as yellowish as in var. *typicum*. For an account of the latter see Smith (1941). In his notes Kauffman had recognized var. *farinaceum* as a distinct species, apparently placing considerable emphasis on the slight difference in spore size and shape ( $4-5 \times 2-3 \mu$  as against  $6-7 \times 2-3 \mu$ ). My measurements for *T. ionides* var. *typicum* were  $5-6 \times 2-3 \mu$ . Lange described *T. ionides* as having a somewhat farinaceous taste, yellowish gills and spores  $5-6 \times 2.7-3 \mu$ . The difference in spore size is certainly not sufficient to justify describing a new species with it as the principle difference, and it appears that one can expect some variation in the taste. This is not in the least surprising. However, in the United States the information at hand indicates that the Michigan collections cited above are constant in the characters mentioned, and the differences cannot be regarded as seasonal variation.

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## A WHITE VARIETY OF *MUTINUS CANINUS*<sup>1</sup>

S. M. ZELLER

(WITH 1 FIGURE)

Members of the Phallales are so uncommon in the Pacific Northwest that the occasional collection of one invokes considerable interest. In August 1942, button stages and mature specimens of a white *Mutinus* packed in soil in which they had grown were mailed to the Botany Department, Oregon State College. Some of the larger buttons about one inch long were planted (in a pot) in the soil in which they had originally grown. They were thoroughly soaked with water and placed in the moderately warm laboratory. By the next afternoon the fructifications had grown to full stature, as illustrated. It proved to be a variety of *M. caninus* (Pers.) Fries, pure white throughout except the gleba. Although this white form has previously been observed<sup>2</sup> it has been included under the typical form with the red colors in the receptaculum. This form is therefore designated as follows:

### *Mutinus caninus* var. *albus* var. nov.

Button stages pure white; volva left at base of receptaculum as a 2-3-lobed clasping cup, outer coat (peridium) becoming sordid whitish, tinted cream, internally a light tan-colored gel, 2-3 mm. thick; receptaculum pure white to the apex, under the layer of olive spores, larger in diameter above than the stem-like portion below; hollow and chambered as in species; pileus (or outer membrane over gleba) white in young stages, practically obsolete at maturity, some brownish remnants, especially at lower margin of spore mass in fresh mature specimens; gleba odor foetid, deep olive (R) and darker; basidia typically phalloid, about 2-3  $\times$  4-8  $\mu$ ; 4-11-spored; spores light muddy olive, 3.5-4  $\times$  1.8-2  $\mu$ .

<sup>1</sup> Published as Technical Paper No. 434 with the approval of the Director of the Oregon Agricultural Experiment Station, Corvallis. Contribution from the Department of Botany.

<sup>2</sup> Lloyd, C. G. Syn. Phalloids. Lloyd Lib. Bul. 13, 1909.

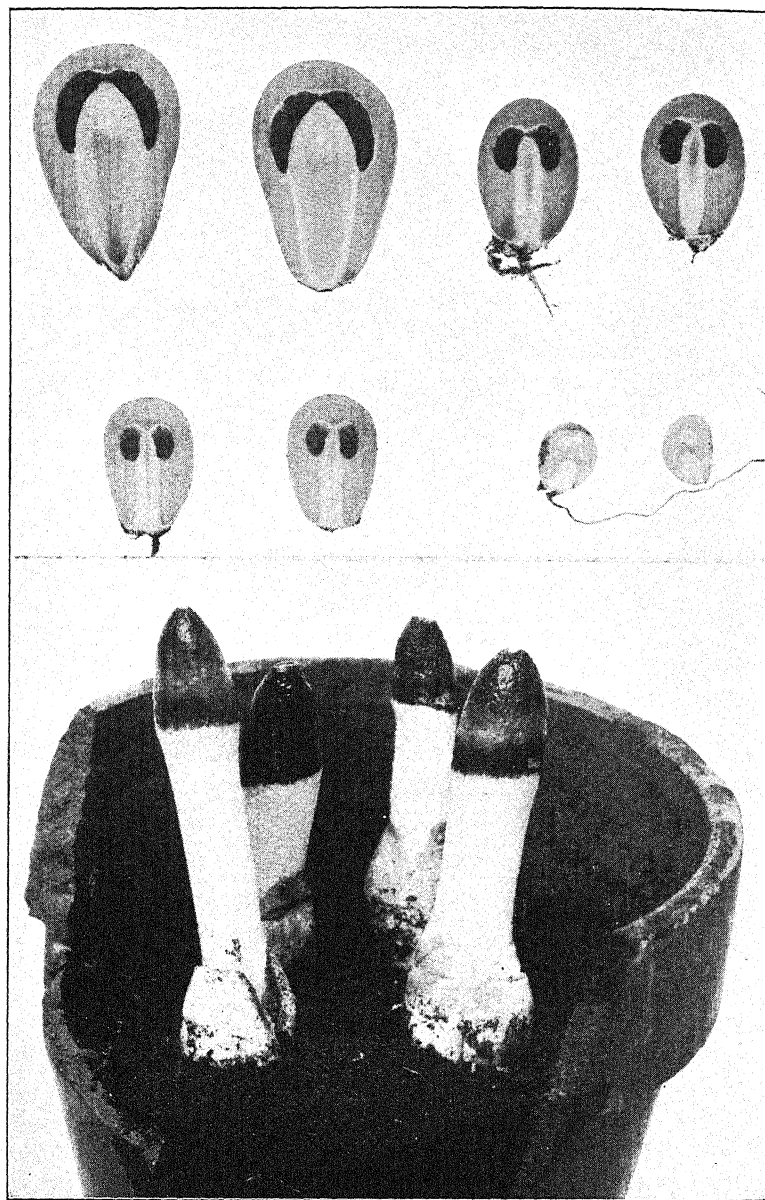


FIG. 1. *Mutinus caninus* var. *albus*.

In very sandy garden soil, Warrenton, Clatsop County, Oregon. Collected by *Maude D. Barlow*, Aug. 13, 1942.

The illustrations show (1) vertical sections of young button stages and (2) mature fructifications reared to maturity in the laboratory. In the sections of young specimens may be seen the pileus or outer sheath of the gleba as it breaks away from the apex of the stem (receptaculum). Burt,<sup>3</sup> dealing with the morphology of *Mutinus Ravenelii*, almost ignores this as remnants of a pileus, although in the summary he says that the formation of the sheaf-like head "reminds one of the changes that occur in the formation of the pileus in some of the Agaricinae." *Mutinus* is an instance where practically all of the fundamental pileate tissue is sloughed off with the volva in mature stages, leaving the gleba as a smear of spores and disintegrated tissue on the surface of the upper portion of the percurrent columella, stem, or receptaculum. To be entirely accurate the genus description should indicate "pileus lacking at maturity."

The photograph of mature specimens in a pot is presented to illustrate a method whereby unmolested fructifications of phal-loids may be obtained for convenient observation or photographs.

<sup>3</sup> Burt, E. A. The development of *Mutinus caninus* (Huds.) Fr. Ann. Bot. 10: 343-372, *illus.* 1896.

# DEVELOPMENT OF THE PERITHECIUM IN ASPERGILLUS FISCHERI WEHMER, WITH A DESCRIPTION OF CROZIER FORMATION

LINDSAY S. OLIVE

(WITH 45 FIGURES)

## INTRODUCTION

*Aspergillus Fischeri* Wehmer is one of three ascosporic species of *Aspergillus* recently obtained in our laboratory on tea leaves by Mrs. Ruth Ellis Allen. The writer obtained the fungus in culture from Mrs. Allen, whose paper surveying the three above-mentioned species is being prepared for publication. *Aspergillus Fischeri* Wehmer is an ascosporic species occurring in the *A. fumigatus* group. We are indebted to Dr. Kenneth Raper for the identification of this species.

The present paper describes the morphology and cytology of perithecial development in *Aspergillus Fischeri*, with a detailed account of crozier formation. Professor John N. Couch first discovered the presence of croziers in this fungus and found that he could best demonstrate them by dissecting the young perithecia under the microscope, rather than by preparing microtome sections. With this in mind, the writer has developed, and will later describe, a rather simple method for preparing slides for cytological study of crozier formation in *Aspergillus*. Apparently, croziers have been overlooked in many Ascomycetes because the investigator has relied too much upon sectioned material.

Dangeard (3), in 1907, described perithecial development in a species which he identified as *Aspergillus fumigatus* Fresenius, but did not observe crozier formation here. Since DeLamater (4) found that croziers were formed in *Arachniotus*, one of the lowest of the Euascomycetes, it is not at all surprising that they are found in *Aspergillus*. Emmons (5, 6) has already reported

crozier formation in *Byssochlamys fulva* and in *Thielavia terricola* of the Aspergillaceae. DeLamater (4) has announced finding croziers in *Penicillium avellaneum*, but has not yet published on this species. Brefeld (1) illustrated for *Penicillium* groups of ascogenous hyphae with hook-like processes; yet he showed the asci in chains, as though they were produced by a budding process. Fraser and Chambers (7), in an investigation of *Aspergillus herbariorum*, and Satina (9), in a study of *Magnusia nitida*, showed asci arising from penultimate cells of hook-like structures, but did not follow this to the fusion of the tip cell with the stipe cell.

The present paper presents the first complete cytological account of crozier formation in the Aspergillaceae, and one of the primary purposes of this paper is to describe a simple technique which will prove useful in the cytological investigation of crozier formation in any Ascomycete with soft perithecia.

#### MATERIALS AND METHODS

The fungus was grown on three types of agar; namely, Czapek's solution agar and our No. 5 (20 gms. agar, 3 gms. maltose, 1 gm. meat peptone, to 1 liter of water) and F-13 (20 gms. agar, 1.5 gms. maltose, 0.04 gms. peptone, to 1 liter of water). Perithecia were formed on all three. On Czapek's solution agar, the growth of vegetative hyphae was too dense for the method of preparation employed here. With our No. 5 agar, there was still too great a production of vegetative hyphae and conidiophores. The best growth of perithecia with a minimum of vegetative growth was obtained on F-13 agar, which has very small quantities of sugar.

Slides showing conidiophores and ascogonial coils were prepared by smearing on the slide in a small drop of Haupt's gelatin some of the mycelium obtained from a culture about three days old. Young perithecia showing ascogenous hyphae within were best studied in sectioned material, while the croziers and young asci were by far most advantageously prepared by the smear technique. With this procedure large numbers of croziers and asci were mashed out of the perithecia and spread out on the slide by pressure exerted on a cover glass placed over the material. All stages from the first appearance of the croziers to the forma-

tion of ascospores were very well shown on slides prepared in this way.

Some of the material, particularly the ascogonial coils, was studied in aceto-carmin preparations. Several stages in crozier formation drawn from such preparations are shown in figures 1-5. However, most of the slides, after being prepared by the smear technique, were dipped directly into one of three killing fluids: formalin-acetic-alcohol solution, Navashin's chromic-acetic-formalin solution, and formalin-acetic-propionic acid solution. Here they were left from 6-24 hours. All three of these solutions proved effective, but the first was used most frequently. The slides were then carried through the iron-alum haematoxylin staining technique already described by the writer (8) for staining nuclei in the basidia of *Gymnosporangium*. The only change was a lengthening of the staining time to 8-12 hours.

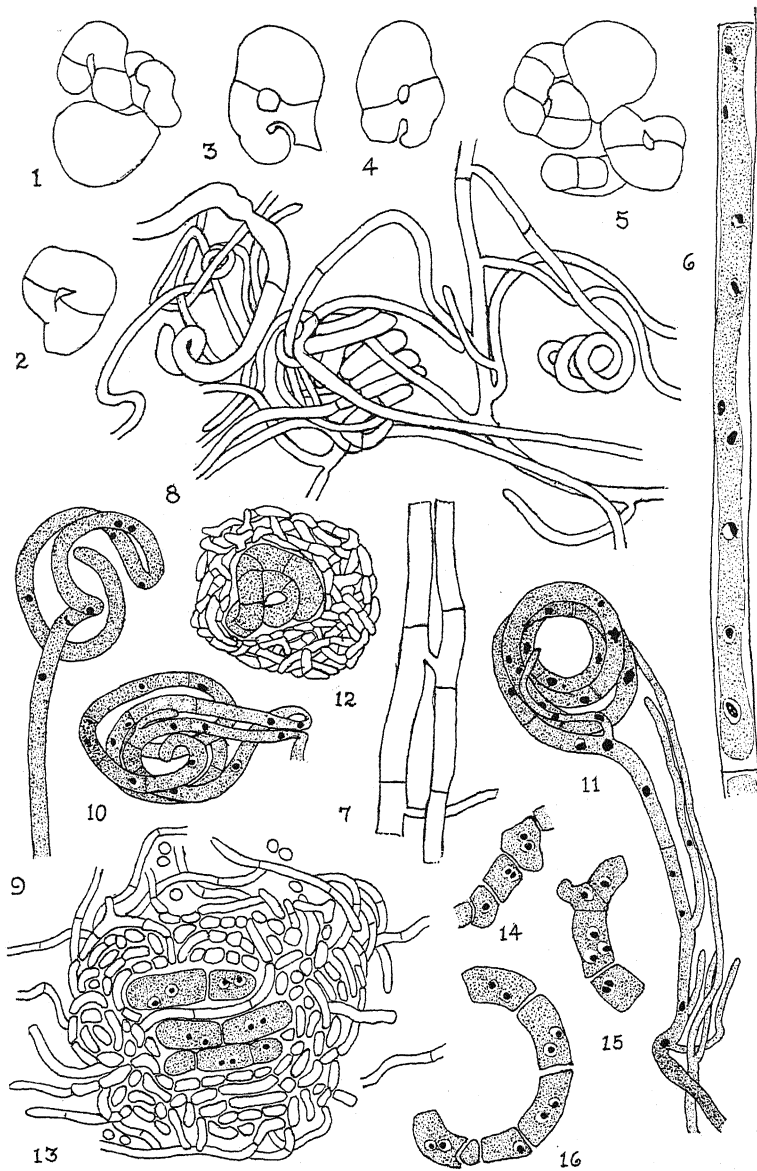
Some of the older perithecia were sectioned before staining, but it is very difficult to demonstrate croziers in this way; in fact, they are more likely to be overlooked entirely in sectioned material.

#### INVESTIGATIONS

From the time of transplanting a small portion of the mycelium of *Aspergillus Fischeri* onto an agar plate, mature perithecia are produced within a week. First to appear are the conidiophores and ascogonial coils. The former cease to be produced after 4 or 5 days growth on agar and eventually disappear entirely. The conidiophores, which are similar to those already described by Dangeard (3) for *Aspergillus fumigatus* Fresenius, will not be treated here.

Vegetative hyphae consist of long cells which are multinucleate (FIG. 6). Nuclei will be described later in connection with the development of the ascogonium. Fusions between vegetative hyphae are frequently observed in this species (FIG. 7).

Ascogonial coils become extremely abundant after about three days growth on agar. The tip of a young hypha extending from a larger hypha in the mycelium begins to coil (FIGS. 8, 9) and continues to do so until it has made from 4-8 turns (FIGS. 8, 10, 11). At first the young hypha is coenocytic, but when the coiling

FIGS. 1-16. *Aspergillus Fischeri* Wehmer.



has ceased, it becomes multiseptate, while the number of nuclei in each cell varies from one to several. At this time, other hyphae begin to grow towards the ascogonium from various points. Some of these hyphae are branches of the ascogonial coil itself (FIG. 10); some arise from the same hypha which gave rise to the coil (FIG. 11); while the majority probably grow in from neighboring hyphae (FIGS. 8, 11). All of these hyphae appear to be purely vegetative in nature. No branch which could be called an antheridium was observed here. Fusions between ascogonium and hyphae growing into the ascogonium were looked for by the writer, but none could be proven.

The growth of vegetative hyphae about the ascogonium eventually becomes so dense (FIG. 12) that it is necessary to section the material in order to observe the next stages of development. Sectioned material shows the coil imbedded in a dense mass of interwoven hyphae, and now the coil is composed of comparatively large cells, most of which are binucleate (FIGS. 13, 14, 16). Each nucleus consists of a dense inner body, the so-called nucleolus, surrounded by a clear area and that bounded by the nuclear membrane, which is not always distinct. The so-called nucleolus is a body which apparently includes, not only the nucleolus, but all of the chromatin in the nucleus as well. No chromatin network is seen outside the densely staining body at this time, and the latter is therefore probably homologous with the "endosphere" described by Savile (10) in unexpanded nuclei of the rust fungi.

Occasionally more than two nuclei are found in an ascogonial cell at this stage (FIG. 15). The end result, however, is a coil of binucleate cells. These cells, as Dangeard (3) has pointed out, appear to become dissociated; that is, although they remain in position for some time, there no longer seems to be any connecting cell walls between adjacent cells (FIGS. 13, 14, 16).

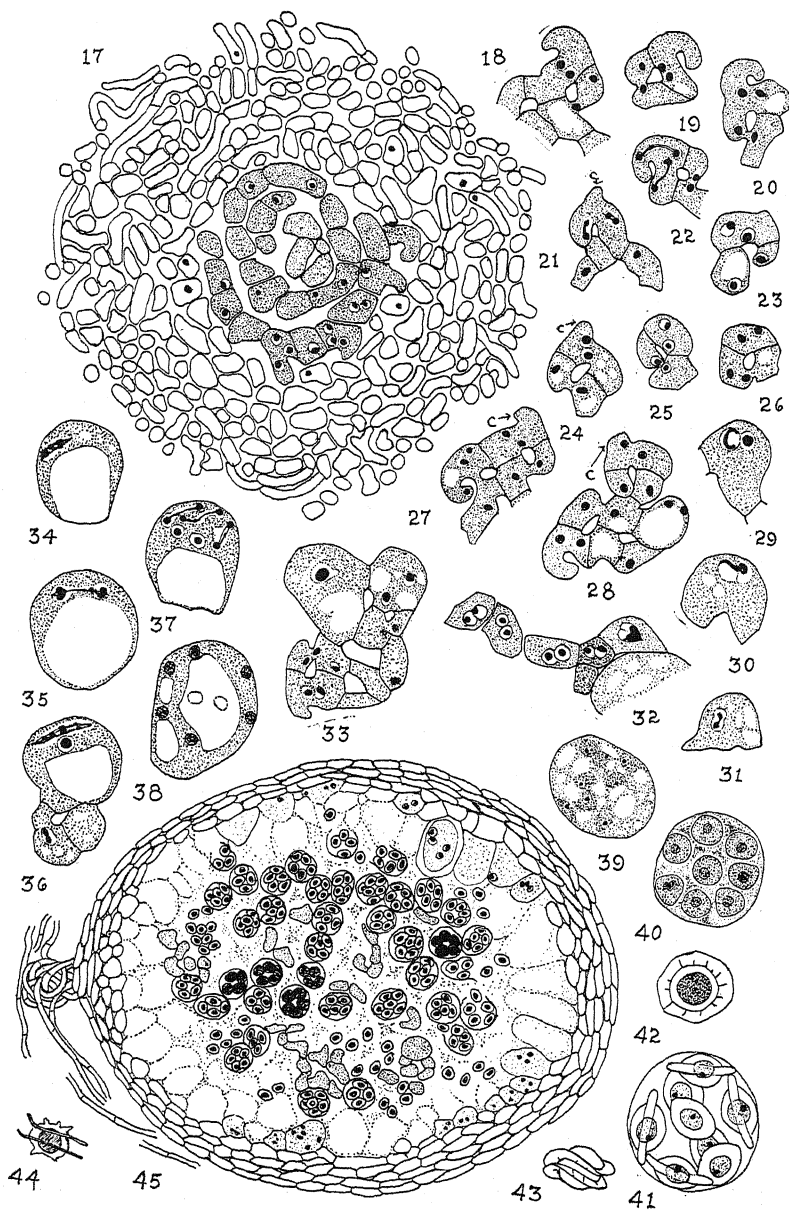
In a few instances it appeared that nuclei were fusing in pairs in some of the ascogonial cells (FIGS. 14, 15). If this is true and of common occurrence, it may be that we have a much reduced form of sexuality here, as Dale (2) has already described for *Aspergillus repens*. On the other hand, it must be admitted that

two nuclei of such small proportions when superimposed could easily be mistaken for fusing nuclei.

Sections through young perithecia at a slightly later stage show ascogenous hyphae beginning to bud out from cells of the coil (FIG. 17). Each bud apparently takes on the form of a crozier from the start, and further proliferation of the ascogenous branch takes place by a continuation of the crozier-forming process. The perithecium continues to increase in size during this development. The growth within is so prolific at this stage that, with a moderate amount of pressure on the perithecium, a great ball of closely packed ascogenous hyphae and croziers may be forced out intact. A slightly greater pressure will disperse these croziers in small groups over the slide so that they are more convenient for study.

The development of this mass of croziers is as follows. Any cell of the ascogonial hypha may produce a bud which hooks around in the form of a typical crozier (FIGS. 17-20). The two nuclei in the hook divide conjugately in planes almost at right angles to one another (FIGS. 21, 22). At the end of this division one nucleus passes into the tip of the crozier and a cross wall appears, cutting off a uninucleate tip. Another cross wall cuts off a stipe cell with a single nucleus, and the penultimate cell is left with a pair of daughter nuclei (FIG. 23). The tip cell of the crozier soon fuses with the stipe, and the nucleus in the latter passes into the crozier tip, thus bringing two daughter nuclei together in the tip cell (FIGS. 18, 24-26). While this development has been taking place, the penultimate cell has given rise to another crozier bud (FIGS. 24, 27, 28, *c*). This new crozier may begin to appear even before nuclear division is completed in the one giving rise to it (FIG. 21, *c*). The binucleate crozier tip may also aid in this proliferation by forming a new crozier (FIGS. 3, 4).

When the ultimate growth of this mass of ascogenous hyphae has been reached, the penultimate cells of the croziers begin to enlarge, rather than form new croziers, and nuclear fusion takes place in each of these cells. These cells are the young asci. As the two nuclei come into contact prior to this fusion, their membranes break down. The nucleus at this stage still con-

FIGS. 17-45. *Aspergillus Fischeri* Wehmer.

sists of a deeply staining body, or endosphere, surrounded by a clear space in which no chromatin is visible. The two endospheres come into contact and fuse into one body, while a clear outer sphere persists around the latter (FIGS. 29-33). Frequently, one of the endospheres becomes elongated as fusion begins (FIGS. 29, 30).

By the time nuclear fusion is completed the ascus is generally considerably enlarged (FIG. 33). Through the coalescence of many smaller vacuoles, a single large vacuole appears near the center, so that the protoplasm is confined to the outer part of the ascus and next to the cell wall (FIGS. 33-38). It is thickest at the distal end of the ascus and this is where nuclear division occurs. The fusion nucleus now undergoes its first meiotic division (FIGS. 34, 35), then a second (FIG. 36), and a third division (FIG. 37), during which spindles appear. The result is an ascus with 8 nuclei (FIG. 38). In some manner a denser aggregation of protoplasm appears about each nucleus (FIG. 39), and this is followed by the appearance of a circular spore wall cutting out the nucleus with some of the surrounding protoplasm (FIG. 40). Some protoplasm is left on the outside of the 8 spores formed within the ascus. The mature ascus shows eight ascospores with conspicuous flanges on their outer walls (FIG. 41). Each spore contains a single nucleus. At maturity, however, no protoplasm is visible in the ascus outside the spores. There is some indication that the flanges on the ascospores are formed from the protoplasm which surrounded the spores just after the appearance of the circular spore walls (FIG. 40). Several mature ascospores were drawn in different views to demonstrate the nature of the flanges, which appear as two conspicuous bands surrounding the spore (FIGS. 42-44).

The perithecium, as it approaches maturity, is filled with asci. The inner wall of the perithecium is lined with large pseudo-parenchyma cells which are disintegrating (FIG. 45). Croziers are very rare or entirely absent at this time. The outer wall of the perithecium is a compact rind made up of small cells and is 3-5 cells in thickness. Eventually all of the larger pseudo-parenchyma cells on the inside of the perithecium disintegrate.

The walls of the asci break open, and the ascospores are freed into the cavity of the perithecium (FIG. 45).

#### SUMMARY

1. A morphological and cytological investigation of perithecial development in *Aspergillus Fischeri* Wehmer reveals that the perithecia have their origin in the numerous ascogonial coils which appear after a few days growth on agar. These coils become septate and invested with a compact growth of vegetative hyphae. No antheridia are found here.

2. The ascogonial coil in the young perithecium eventually becomes divided into binucleate cells which bud out to form the ascogenous hyphae.

3. Ascogenous hyphae proliferate greatly by means of crozier formation, while the perithecium increases in size.

4. Towards the end of this period of proliferation, the penultimate cells of the croziers enlarge to form asci. The two nuclei in each of the young asci fuse. This is followed by three karyokinetic divisions which result in an 8-nucleate ascus. Eight ascospores are cut out around these nuclei. The mature ascospore is uninucleate and has two conspicuous flanges surrounding it.

5. The mature perithecium is filled with asci whose walls eventually disintegrate and liberate their spores into the perithecial cavity.

#### ACKNOWLEDGMENT

The writer is grateful to Professor John N. Couch for his assistance during the course of this study and to Mrs. Ruth Ellis Allen, who furnished the specimens of *Aspergillus Fischeri* for culture and investigation.

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#### EXPLANATION OF FIGURES

(All figures  $\times 1495$ , except where indicated.)

FIGS. 1-45. *Aspergillus Fischeri* Wehmer. 1-5, croziers and young asci pressed out of a perithecium, untreated; 6, single cell of a hypha stained to show nuclei,  $\times 1015$ ; 7, hyphal fusion,  $\times 665$ ; 8, ascogonial coils and adjacent hyphae, from aceto-carmin preparation,  $\times 1015$ ; 9, young non-septate ascogonial coil; 10, 11, septate ascogonial coils, showing origin of vegetative hyphae forming perithecial wall; 12, enlarged ascogonial coil surrounded by interwoven vegetative hyphae,  $\times 1015$ ; 13, young perithecia showing ascogonium with binucleate cells; 14-16, portions of ascogonia, showing tendency of cells to dissociate; 17, young perithecium with ascogonium giving rise to ascogenous branches in the form of croziers; 18-28, steps in crozier development, some figures showing formation of new crozier buds (c) from penultimate cells; 29-33, nuclear fusion in the young asci; 34, 35, first meiotic division in the ascus; 36, second division, one nucleus not yet undergoing division; 37, third division; 38, 8-nucleate ascus; 39, 40, appearance of the ascospores; 41, mature ascus; 42-44, ascospores in various views; 45, mature perithecium,  $\times 443$ .

## A NEW SPECIES OF CRINIPELLIS FROM OHIO

ALEXANDER H. SMITH AND MAURICE B. WALTERS

(WITH 1 FIGURE)

### *Crinipellis maxima* sp. nov.

Pileus 2–4 cm. latus, obtusus demum late campanulatus vel plano-umbonatus, subzonatus, siccus, fibrillosus, fuscus, ad marginem sordide luteo-fuscus; lamellae albae adnatae, confertae; stipes 4–6 cm. longus, 3–5 mm. crassus, aequalis, subradicatus, fusco-tomentosus; sporae 8–10 (11)  $\times$  4–5.5  $\mu$ ; cheilocystidia 42–66  $\times$  9–13  $\mu$ .—Specimen typicum in Herb. Univ. of Mich. et Farlow Herb., Harvard Univ. conservatum: Legit Maurice B. Walters, prope Cleveland, Ohio, Aug. 25, 1943.

Pileus 2–4 cm. broad, obtuse when young, the margin incurved and the disc flattened, becoming broadly campanulate to plano-umbonate, the disc abruptly depressed, somewhat zonate around the disc by concentric depressed lines, surface dry, appressed-fibrillose or fibrils arranged in appressed fascicles, disc unpolished as well as tuberculate and cinereous, area surrounding the disc "fuscous" or slightly paler (dark grayish brown), "bister" (dark yellowish brown) over the marginal area; flesh thin, white, pliant, reviving well, odor and taste not recorded; lamellae white, narrowly adnate, seceding, close to crowded, ventricose, edges white-fimbriate; stipe 4–6 cm. long, 3–5 mm. thick, equal, the base somewhat fusiform and tapered to a point or with a short pseudorhiza, pallid beneath a dense tomentose coating of umber fibrils or the fibrils tufted and giving a somewhat tomentose-scaly appearance, pallid within.

Spores 8–10 (11)  $\times$  4–5.5  $\mu$ , smooth, hyaline, narrowly ellipsoid, many pseudo-amyloid in age; basidia 28–33  $\times$  7–8  $\mu$ , four-spored, hyaline in KOH; cheilocystidia abundant, hyaline, thin-walled, 42–66  $\times$  9–13  $\mu$ , fusoid ventricose at first, the apex becoming elongated to a flexuous, filamentose but rarely branched proliferation 2–3.5 in dia.; pleurocystidia found only near the gill edge and similar to cheilocystidia; gill trama hyaline in KOH, dark rusty brown in iodine, central strand of somewhat interwoven elongated thin-walled cells 10–14 in dia., appearing cellular in section toward the subhymenium; pileus trama with the central body of hyaline thin-walled hyphae (4) 6–12 in dia., rather compactly interwoven and becoming dark reddish brown

in iodine; the cuticle of the pileus consisting of long acutely pointed thick-walled hairs which are flexuous to contorted over the basal portion but gradually even out to the acute apex,  $4-7\ \mu$  in dia.,  $300\ \mu$  or more long, either aseptate or with numerous

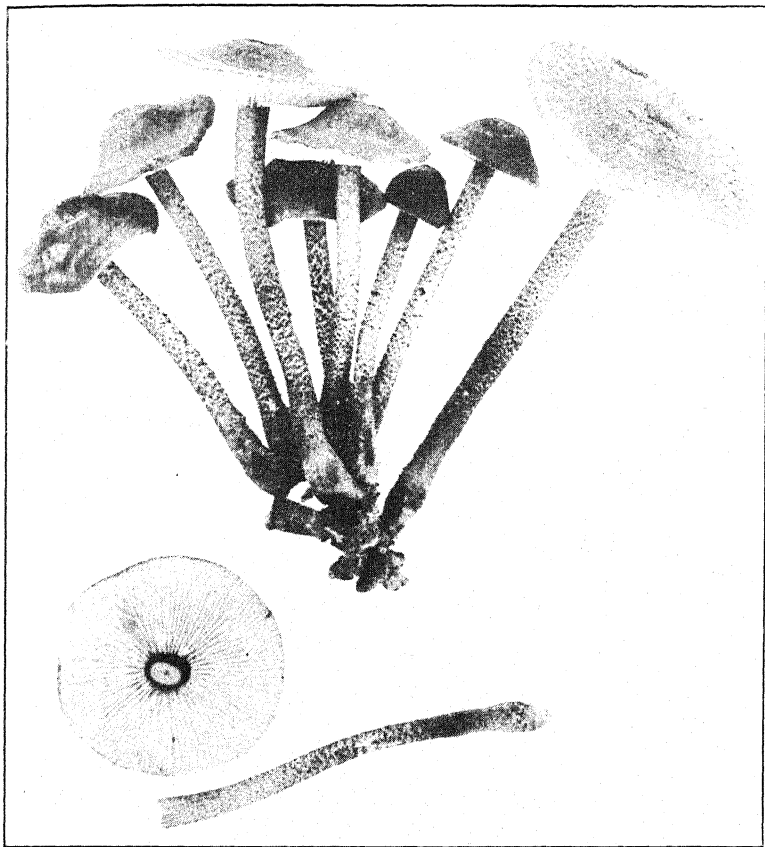


FIG. 1. *Crinipellis maxima* Smith and Walters,  $\times 1$ .

secondary septae within  $50-100\ \mu$  of the apex, the walls dark reddish brown in iodine, pale yellowish in KOH, and with clamp connections at the basal septae.

Cespitose in a brook-bed in mud and shale fragments, near Cleveland, Ohio, Aug. 25, 1943, collected by Maurice B. Walters.

Observations: The identification of the known species of *Crinipellis* has finally been placed on a scientific basis as the result



of the work of Singer.<sup>1</sup> As frequently happens when such a publication appears, and it is possible for other mycologists to critically evaluate their collections, interesting results are obtained. In this instance the first species to come to our attention was found to be undescribed. As a final check, material of the Ohio collection was sent to Dr. Singer for examination. He verified our opinion that the fungus was undescribed, but closely related to *C. hirticeps* (Peck) Singer. The outstanding character of the fungus, and the one emphasized by Dr. Singer in his letter, is the shape of the cheilocystidia. Since the fungus differs from *C. hirticeps* in other characters as well, we have described it as a species rather than as a variety of Peck's species. Habitat is an important character in *Crinipellis*, and to say the least, the habitat of *C. maxima* is peculiar, although more observations are needed to verify that the fungus is not typically lignicolous. Although the cluster was found growing in a mixture of shale fragments and the clay-like mud into which the shale disintegrates, it was actually very close to the root-tangled bank and the mycelium could easily have been attached to rotting roots. The brook bed was in the bottom of a ravine heavily wooded with a mixture of deciduous trees. Figure 1 shows the manner in which the carpophores develop from the mycelial strands.

ANN ARBOR, MICHIGAN

<sup>1</sup> A monographic study of the genera *Crinipellis* and *Chaetocalathus*. De Lilloa 8: 441-534. 1942.

## NOMENCLATURE OF FUNGI

G. R. BISBY

Everyone who uses scientific names may be affected by rules of nomenclature. Mycologists get along surprisingly well with their nomenclature, considering the small amount of effort most of them have given to the formulation of rules for their guidance. A review of some of their nomenclatural problems, and suggestions for a few possible interpretations, revisions, or additions to the rules may, it is hoped, prove useful for discussion; especially since the adoption in 1930 of the type method necessitates reconsideration of much past procedure.

The International Rules of Botanical Nomenclature, first adopted at Vienna in 1905, were based on de Candolle's "Lois" of 1867. These rules covered many of the fundamental problems of nomenclature of all plants. Fungi were not specifically considered. The Brussels Congress in 1910 revised the rules and added (evidently from proposals by Saccardo (1), who did much to keep mycological nomenclature on a fairly even keel, and by a group of American mycologists (2)) the articles now numbered 57 and 20, and three or four recommendations, all applying definitely to fungi. This second edition of the rules, published 1912, was followed by the third (the present) edition printed in 1935 which, as regards fungi, has practically no change from the second except the addition of Recommendations VI and VII and a list of proposed *nomina generica conservanda*. The Congress at Amsterdam in 1935 did not pass alterations specifically affecting nomenclature of fungi.

Meanwhile certain American workers had done valuable work for nomenclature in developing the "American Code."

Mycologists could, if they wished, formulate their own rules of nomenclature (as was recommended by a number of botanists at Vienna), but I presume the majority would now vote to continue to follow, after emendation, the rules used by other botanists.

Nomenclature cannot answer questions of taxonomy. Though it aims at fixity of names, the avoidance of error, of ambiguity, and of useless creation of names, it must recognize that an author is at liberty to combine generic names and specific epithets, or to propose families or orders, in any way that seems best to him. If, inadvertently or deliberately, he breaks the rules others who follow them—the majority of mycologists—will correct his nomenclature or ignore his work.

The rules do not attempt to obviate the use of judgment; on the contrary, the suggestion is made that their spirit rather than their letter should be followed: "In the absence of any relevant rule, or where the consequences of rules are doubtful, established custom must be followed." This is one of the principles upon which the rules are based.

At the present time there are two important rules concerning which differences of opinion obtain. The first is Article 57 dealing with the nomenclature of the different "successive states" of a species and the second is Article 20f regarding the starting points of the various groups. In the following paragraphs I venture to outline my personal views on these articles in the hope that they will help to clarify the situation.

**SPECIES, STATES, AND ARTICLE 57.** "Names of species are binary combinations consisting of the name of the genus followed by a single specific epithet" (Art. 27). Nomenclature does not presume to say what shall constitute a species, except that its name should have a type specimen or preparation, though a description or figure may suffice. The rules also recognize that, in fungi, names are often given to imperfect states.

A state of a species of fungi is imperfect or perfect. An imperfect state may be a mycelial, a spermogonial, a pycnidial, or other conidial state. The perfect state is that which produces basidiospores, ascospores, zygosporos, or oöspores, together with associated structures which protect these spores.

"Stage" is commonly used as a synonym of "state," but "stage" involves an idea of regular succession, whereas states of fungi may occur simultaneously or in varying order.

Let us consider a few examples.

1. Most fungi have mycelium. This vegetative state is seldom named unless it has distinctive mycelial structures; then, if it seems advisable, the state can be considered to represent a species pending further information, given a binomial which has the same rules and rights as any other binomial, and the name classified in the Mycelia Sterilia of the Fungi Imperfecti. Examples: *Sclerotium durum* Fries,<sup>1</sup> *Rhizoctonia Crocorum* Fries.

2. A fungus may have a spore-producing imperfect state (and generally mycelium also, though this may not be evident unless the fungus is grown in culture). This state is usually self-perpetuating and, if it is the only one known, it needs and gets a binomial. This name also represents a good species of the Fungi Imperfecti, at least *pro tem*.

Mycologists formerly assumed that the large group of Fungi Imperfecti would gradually disappear through the discovery of perfect states, and considered that each species then should bear only one name, that of the perfect state: the rules still say "generic and specific names given to other states have only a temporary value." Mycologists now realize, however, that the temporary value commonly becomes permanent. It has become "established custom" to continue to use the name of an imperfect state, after its perfect state is demonstrated, if this be necessary or desirable in order to avoid ambiguity. Thus *Helicobasidium purpureum* Pat. has been shown to be the perfect state of *Rhizoctonia Crocorum*; but the latter binomial may, so far as known, represent the species in various regions or examples. Its use obviates the circumlocution "*H. purpureum* Pat., stat. mycel. steril." Furthermore, it may not be certain that *H. purpureum* represents the perfect state of *all* that passes under the name of *R. Crocorum*. In order to recognize these facts, it seems better to say that the "name applied to the . . . perfect form shall take precedence," as was proposed in 1910 (2). It will also be understood that the type specimen of *R. Crocorum* could be

<sup>1</sup> Or *S. durum* Pers. ex Fr. Pre-Friesian (and other pre-valid) authors and names are here omitted, just as Phanerogamists generally omit pre-Linnaean. In formal taxonomic treatises, especially if a specimen of Persoon's had been found or chosen as type, "Pers. ex Fr." would be more explanatory and accurate.

designated the type of its *Helicobasidium* only if it were definitely found to bear that perfect state.

3. A species having a named mycelial state (e.g. *Sclerotium durum*) may prove to have also a conidial state (*Botrytis cinerea* Fries). Both belong to the Fungi Imperfecti, but a spore-producing state is generally recognized as "higher" than (i.e., takes precedence over) a mycelial state, and, as it became clear that both are regularly associated, the name *S. durum* rightly fell out of common use. Though the rules do not (and probably cannot) provide for the extinction of a binomial, the name *S. durum* should be used only in exceptional instances (say in a monograph of *Sclerotium*) for the name of a state of a species. But it seems most unlikely that *B. cinerea* will in turn be so nearly completely superseded by the name of its supposed perfect state, *Sclerotinia Fuckeliana* (de Bary) Fuckel.

4. A species may be known as a perfect state (and generally mycelium) only. An un-named conidial state found later must not, according to the present rules, receive a binomial in the Fungi Imperfecti. "Established custom"—a Principle—sometimes overrides this rule, but should do so only when distinct advantage is gained. If it be demonstrated that a conidial state with a prior name belongs to a species with a named perfect state, the rules say that one cannot legally propose a new combination and the type method makes this impossible unless the type specimen of the imperfect state also bears the perfect. In the Uredinales, however, the usual practice is to accept *Uredo* names as having equal status with names applied to telia. Arthur and others hold that is is legal because the uredo state is part of the perfect state.

5. A perfect state may be demonstrated for a species previously known only as a named imperfect state. According to my reading of the present rules, the "temporary value" of the latter name would end when the perfect state was described and named, the type specimen of the specific name would be that of the perfect state, and the name of the imperfect state should be dropped or cited only as a synonym. If, for example, a perfect state is described and named "*Mycosphaerella Aleuritidis* (Miyake) Ou (1940), syn. [the imperfect state] *Cercospora Aleuritidis* Miyake

(1912)" I take it that the binomial should be cited "*M. Aleuritidis* Ou (1940)," since the type specimen of the name of a *Cercospora* cannot (or at least should not) be made the type specimen of the name of a *Mycosphaerella* unless the specimen is shown to bear the perfect state. Once more, however, a wording that "the name of the perfect state takes precedence" should legalize the retention, when advisable, of the binomial *C. Aleuritidis* for the imperfect state.

6. A few species (e.g., of *Aspergillus* and *Penicillium*) have perfect and imperfect states, but a name for the imperfect state only. This usage fulfils the principle of "avoidance of all useless creation of names," but if continued perhaps should be regularized by conserving the generic name (or redefining the genus) to include the perfect state.

These numbered paragraphs apply to Fungi Imperfecti on the one hand, to Basidiomycetes and especially Ascomycetes on the other. But the imperfect states of Phycomycetes—commonly more important or distinctive than the perfect state, if that be produced—are seldom classified in the Fungi Imperfecti. It is "established custom" to accept the first valid epithet or generic name applied to either state of a Phycomycete, and Article 57 does not forbid this custom for Phycomycetes. The custom could not now be changed without introducing much uncertainty as to names and authors of numerous Phycomycetes (3, 4).

The re-wording of Article 57 should depend largely upon the views of the majority of mycologists upon such examples and principles as are given above. I suggest this for your criticism:

57. In Ascomycetes and Basidiomycetes (but not Phycomycetes) with pleomorphic life-cycle, the first valid name or epithet applied to the perfect state (that producing asci or basidia, together with the appropriate associated structures; in Uredinales, to the *Uredo* or telial stage) takes precedence. Similarly, the name or epithet of a spore-producing state takes precedence over that applied to a mycelial state. The type specimen of a state must bear that state. The author who first describes a perfect state is at liberty to use the specific epithet of the imperfect state, but his binomial of the perfect state is to be attributed to him alone.

ARTICLE 20F. Various interpretations can be given to the words "Legitimate botanical nomenclature begins for Fungi caeteri [Eumycetes, excluding Uredinales, Ustilaginales, and Gasteromycetes] at 1821-32 (Fries, *Systema mycologicum*)."

The American proposal (2) stated: "we are in favour of adopting Fries's *Systema* in view of the fact that it includes a much larger number [than Persoon's *Synopsis*] of widely distributed genera and species." From this, and from experience, I gather that validation was intended to apply, and should apply, mainly to specific epithets and generic names. Please criticize this procedure: given a pre-*Systema* binomial, start with the epithet. If found (say *via* the Index of vol. III, under any generic name) accepted in *Systema* vol. I (1821), vol. II (1822 or 1823), or vol. III (1829 or 1832), consider the epithet validated by that acceptance and at that date, regardless of the group in which Fries placed it (5, 6, 7, 8). Similarly, but secondarily, proceed with the generic name. Pay attention to "validation" by Fries of higher groups only in this sense: an epithet or generic name not included in the *Systema* is not in need of validation if published after Fries had dealt with the genus or higher group to which it belongs; e.g., all epithets of *Agaricus*, and most epithets and generic names of other Hymenomycetes, are "post-*Systema*" if published after Jan. 1, 1821; but most Hyphomycetes remain "pre-*Systema*" until after 1832. As for *Elenchus* I and II (both 1828), I give it no more "priority" than any other work of the same date (but see 10). It is true that Fries cites his *Elenchus* in the Index to the *Systema*; but he also cites references to *Linnaea*.

OTHER COMMENT. The American proposal of 1910 (2) recommended: "The subdivisions, or 'tribes,' of *Agaricus* used by Fries in his *Systema Mycologicum* are to be treated as having been employed as genera at the time of publication of this work." This was not adopted at Brussels, but was proposed anew by Dodge in 1934 (9). Dodge's proposal was not adopted at Amsterdam, but is still before Congress, so that one may now cite names and authorities of agarics either way. It is evident that mycologists, particularly those dealing with taxonomy of Agaricaceae, should give this proposal their considered opinion. I believe that phanerogamists would (or at least should) not

outvote mycologists if the latter can present the view of the majority.

Likewise, though proposals for *nomina specifica conservanda* have been rejected by Congress, I (3, 4) am anxious to know and to accept the verdict of the majority of mycologists on such a proposal for names of fungi. Let us take steps to ascertain that verdict.

There is no objective test for "right and wrong" in nomenclature. The rules can be enforced only so far as they are "used by the great majority of botanists in all countries" (Art. 1). Let us have thought, discussion, and considered opinion on proposed amendments. It seems to me that mycologists—at least, as a start, in English-speaking parts of the world—should be able to come to an agreement on most of the points at issue over rules of nomenclature. But all that I have written above gives merely my own views (at present), and is offered for your criticism.

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*References:* 1. SACCARDO, Trans. Brit. Myc. Soc. 2: 80-84 (1905); 2. ATKINSON, BLAKESLEE, BURT, CLINTON, J. J. DAVIS, DEARNESS, DUGGAR, DURAND, EDGERTON, FARLOW, FAULL, GALLOWAY, HARPER, HOLWAY, L. R. JONES, KAUFFMAN, LYMAN, MACBRIDE, OLIVE, PECK, SEYMOUR, SHELDON, E. F. SMITH, F. L. STEVENS, STURGIS, THAXTER, Motions relating to the rules for nomenclature of the fungi proposed for action at the third international Botanical Congress at Brussels, 14-22 May, 1910; 3. BISBY, Phytopathology 32: 644 (1942); 4. Trans. Brit. Myc. Soc. 25 (1942); 5. BISBY & MASON, *ibid.* 24: 128 (1940); 6. WAKEFIELD & BISBY, *ibid.* 25: 52 (1941); 7. ROGERS, Mycologia 33: 568 (1941); 8. *Ibid.* 34: 215 (1942); 9. C. W. DODGE, Ann. Mo. Bot. Gard. 21: 709 (1934); 10. RAMSBOTTOM, Trans. Brit. Myc. Soc. 18: 316 (1934).



## FUNGI OF THE NORTHWESTERN HIMALAYAS: USTILAGINALES

B. B. MUNDKUR

(WITH 1 FIGURE)

The fungi on which this report is based were collected in North Western Himalayas by Dr. R. C. Stewart and Mrs. I. D. Stewart. The smut collections consisted of 21 specimens, of which two have been found to be new species and five are new records for India. Three specimens are portions of smuts sent by Dr. Stewart to Dr. G. P. Clinton of Yale University some years ago, two of them being on *Polygonum* spp. and the third on *Andropogon annulatus*, a grass now known by the binomial *Dicanthium annulatum* (Forsk.) Stapf. All three specimens were named *Ustilago utriculosa* (Nees) Tulasne by Clinton and Zundel (1938). The smut on the grass is undoubtedly *Sphacelotheca annulata* (Ellis & Ev.) Mundkur. As for the other two smuts identified as *Ustilago utriculosa*, this is a collective species which has been critically studied by Liro (1924) who has segregated it into a number of species on distinct morphological characters. One of the specimens on *Polygonum* agrees with *Ustilago Cordai* Liro and the other on a similar host with *Ustilago reticulata* Liro. These identifications have been confirmed by a comparison with Sydow's Ustilagineen nos. 168 and 59, respectively, which are cited by Liro (1924) as representing his concept of these species.

Among the collections is a smut on *Grewia villosa*, remarkable for the fact that it occurs on the stems of a woody plant. Its characters agree in all respects with the genus *Xylosorium*, recently proposed by Zundel (1939) for a smut on another woody plant, *Piper* sp. Comparison with *Ustilago Grewiae* (Passer.) Hennings, received from the Mycological Herb. Royal Bot. Garden, Peradineya, Ceylon, indicates that both are one and the same species.

The genus *Xylosorium* was established by Zundel (1939) for the reception of a smut occurring on the stems of a woody plant,

with 3-4 septate pustules that are covered by a hard coriaceous membrane which ruptures irregularly at maturity, disclosing a dark-brown, semi-agglutinated spore mass, the spore balls disintegrating into single spores at maturity. It will be noted that the characters in which it differs from *Ustilago* are, principally, the locular pustules and the hard coriaceous layer enclosing them. As for the semi-agglutinated spore mass and the spore balls that disintegrate at maturity, the immature sori of several species of *Ustilago* also show such characters.

However if the other characters enumerated above justify the establishment of a separate genus, then the logical name that should be applied to it is *Pericladium*, proposed by Passerini in 1875 for accommodating the smut on *Grewia*. Passerini (1875) thought that his monotypic genus *Pericladium* belonged to the Uredinales but Hennings (1900) showed that the fungus is a smut and transferred it to the genus *Ustilago*.

I consider that both this smut and the smut on *Piper* sp. from Transvaal, deserve a place in a separate smut genus because of the peculiarities noted above. The name *Pericladium* of Passerini (1875), which precedes the name *Xylosorium* proposed by Zundel (1939), is accordingly transferred from the Uredinales to the Ustilaginales, a procedure which is permissible, as it involves only a question of interpretation of a structure; Zundel's *Xylosorium* thus becomes a synonym.

The spores of the *Grewia* smut in the Stewart collection were (18-4-1938) viable and they germinated by the formation of a septate promycelium. This shows that the position of the genus *Pericladium* is in the Ustilaginaceae. Zundel's *Xylosorium Piperii*, portion of the type collection of which was kindly sent to me by Dr. E. M. Doidge of Transvaal, is renamed *Pericladium Piperii* (Zundel) Mundkur, comb. nov.

New records are preceded in this report by an asterisk (\*) and new species and new combinations are in bold face type; new hosts are preceded by two asterisks (\*\*).

It gives me very great pleasure to place on record my deepest gratitude to Dr. R. R. Stewart and his wife, Mrs. I. D. Stewart, for placing their collections at my disposal for identification. Very few botanists in India have collected fungi so extensively

as they have done and their collections have immensely enriched our knowledge of the Indian fungi, and incidentally helped in make more representative the *Herb. Crypt. Ind. Orient.* of this Institute. Portions of specimens have also been placed in the



FIG. 1. Left, *Pericladium Grewiae*; right, *P. Piperii*.

mycological herbarium of The New York Botanical Garden by Dr. Stewart. My thanks are due to Rev. Dr. H. Santapau, S. J., Professor of Botany, St. Xavier's College, Bombay, for the latin translations of the diagnoses of new species.

#### USTILAGINACEAE

1. \*USTILAGO CORDAI Liro, Die Ustilagineen Finnlands I, p. 12. 1921.

Syn. *Ustilago utricolosa* Clinton & Zundel [*nec* (Nees) Tulasne],  
*Mycologia* 30: 280. 1938.

On *Polygonum* sp.; Kangan-Gund (Kashmir, 6000 ft.), Sept. 7, 1922, No. 7536.

2. USTILAGO CYNODONTIS P. Henn. Engler's Bot. Jahrb. 14: 369. 1891.

On *Cynodon Dactylon* (L.) Pers. Bandipur (Kashmir, 5000 ft.) July 18, 1940, No. 19422.

3. USTILAGO HORDEI (Pers.) Lagerheim, Mitt. Badischen Bot. Ver. p. 70. 1889.

On *Hordeum vulgare* L. Sonamarg, Sind Valley (Kashmir, 9400 ft.), Aug. 31, 1940, No. 21283 (with *U. nuda*).

4. USTILAGO NUDA (Jensen) Rostrup, Tidsskr. Landökonomi 8: 745. 1889.

On *Hordeum vulgare* L. Skardu, Baltistan (Kashmir, 11,000 ft.), Aug. 5, 1940; above Sonamarg, Sind Valley (Kashmir, 9400 ft.), Aug. 31, 1940, No. 21283.

5. \*USTILAGO RETICULATA Liro, Die Ustilagineen Finnlands I, p. 20. 1921.

Syn. *Ustilago utriculosa* Clinton & Zundel [*nec* (Nees) Tulasne], Mycologia 30: 280. 1938.

On *Polygonum* sp. Pahlgam (Kashmir, 7300 ft.), Sept. 14, 1920, No. 5801 (the date cited by Clinton and Zundel (l.c.) is incorrect).

6. USTILAGO TRITICI (Pers.) Jensen, in Kellerman and Swingle, Ann. Rep. Kansas Agric. Exp. Sta. 2: 262. 1890.

On *Triticum vulgare* Host, Baltistan (Kashmir, 10,000 ft.), Aug. 15, 1940.

7. SPHACELOTHECA ANNULATA (Ellis & Ev.) Mundkur, Trans. Brit. Myc. Soc. 23: 92. 1939.

Syn. *Ustilago utriculosa* Clinton & Zundel [*nec* (Nees) Tulasne], Mycologia 30: 280. 1938.

On *Dicanthium annulatum* (Forsk.) Stapf, Pathankot (Punjab plains), May 11, 1917, No. 1776.

8. SPHACELOTHECA CRUENTA (Kuehn) Potter, Phytopathology 2: 98. 1912.

On *Sorghum halepense* Pers. Sialkot, Sept. 9, 1935, No. 15034.

9. *SPHACELOTHECA SCHOENANTHI* (Syd. & Butler) Zundel, Mycologia 22: 136. 1930.

On\*\* *Cymbopogon schoenanthus* (L.) Spreng., Hassan Abdal (Attock Dt.), April 1934, No. 13876A; Margalla (Rawalpindi Dt.), May 1934, No. 13882.

10. \**Sphacelotheca Stewartii* Mundkur, sp. nov.

Ovaricola. Sori ad  $10 \times 5-8$  mm., primo membrana firma, persistente, falsa circumdati, deinde dehiscentes in apice et patefacientes sporarum massas aureobrunneas; columella prominens, apice furcato. Sporae in laxis globulis qui cito degenerant atque evadunt pulverulenti; sporae "snuff brown" (Ridgway), globosae, subglobosae vel ellipsoideae, nonnullae tenuiter angulares, magnitudinis  $7.4-13.0 \mu$  diam. medietate  $10.4 \mu$ ; epispora relative minus densa, superficie minute sed prominenter excavata vel punctata; germinatio per septatum promycelium terminaliter atque lateraliter sporidiis ornatum.

Typus lectus a R. R. Stewart (No. 20793) super Pennisetum flaccido Griseb. in loco Baltistan (in via ex Kasurmik ad Doghani, Kashmir) die 16 Augusti 1940; ab eodem R. R. Stewart (No. 21140) iterum lectus in loco Dras (in via Ladak, Kashmir) die 28 augusti 1940; typus positus in Herb. Crypt. Ind. Orient. New Delhi.

Ovaricolous. Sori up to 1 cm. long, 5-8 mm. broad, at first enclosed by a firm false membrane, later dehiscing at apex exposing "auburn" coloured spore masses; columella prominent, protruding out of the sorus, forked at tip. Spores forming loose spore balls, soon disintegrating and then pulverulent; spores "snuff brown" (Ridgway), globose, subglobose, or ellipsoidal, some slightly angular,  $7.4$  to  $13.0 \mu$  in diameter with a mean of  $10.4 \mu$ ; epispore comparatively less thick, surface minutely but prominently pitted; germinating by means of a septate promycelium with terminal and lateral sporidia.

On \*\**Pennisetum flaccidum* Griseb. Baltistan (Kashmir, 9000 ft.), Aug. 16, 1940, No. 20793 (Type); Ladak road (Kashmir, 9000 ft.), Aug. 28, 1940, No. 21146. Type deposited in Herb. Crypt. Ind. Orient.

11. \**CINTRACTIA ELYNAE* Sydow, Ann. Myc. 22: 289. 1924.

Syn. *Cintractia hyperborea* Ciferri, Ann. Myc. 29: 64. 1931.

*Cintractia chinensis* Yen, Contr. Inst. Bot. Nat. Acad. Peiping 3: 41. 1937.

In ovaries of \*\* *Kobresia capillifolia* C. B. Clarke, at Burzil Chowki (Kashmir, 12,000 ft.), July 28, 1940, No. 19991. The host of Sydow's (1924) fungus is *Elyna spicate* Schrad. = *Elyna*

*Bellardii* Koch, = *Kobresia scirpina* Willd. Ciferri gives the host of his fungus as *Kobresia Bellardi* and Yen (1935) as *Kobresia scirpina* Willd. Measurements of spores given by Sydow are 14–20  $\mu$ , by Ciferri, 16 to 24  $\mu$  and by Yen, 15 to 20.4  $\mu$ . The measurements of the spores in the present collection are 15.8 to 22.4  $\mu$ .

12. \**Cintractia Kobresiae* Mundkur, sp. nov.

Ovaricola; sori emergunt ex glumis ut corpora nigra, globosa, valde firma; columella nec emergens nec prominens. Sporarum massae primo coopertae albo operculo, quod cito degenerat, sed sporae simul agglutinatae et dirimiter tentae, raro pulverulentae. Sporae ovatas, irregulariter ellipsoideae, planae, nonnullae obtuse angulares, colore "Saccardo's umber" (Ridgway), diam. 12.1–17.7  $\mu$ , medietate 15.4  $\mu$ ; epispora crassa, superficie minute echinulate; germinat per septatum promycelium lateralibus atque terminalibus sporidiis ornatum.

Typus lectus a R. R. Stewart (No. 20357) in loco Satpura, in rivo super Skardu, Kashmir in ovariis *Kobresiae laxae* Boeck. atque positus in Herb. Crypt. Ind. Orient.

Ovaricolous. Sori protruding out of the glumes as globose, black bodies, very firm; columella not protruding out or prominent. Spore masses at first covered by whitish covering soon wearing away but spores sticking together and firmly held, rarely powdery. Spores oval, irregularly ellipsoidal, flat, several bluntly angled, "Saccardo's umber" (Ridgway), 12.1 to 17.7  $\mu$  in diameter with a mean of 15.4  $\mu$ ; episore thick, surface minutely echinulate; germinating by means of a septate promycelium with lateral and terminal sporidia.

In ovaries of \*\**Kobresia laxa* Boeck. at Satpura-nulla, above Skardu (Kashmir), Aug. 3, 1940, No. 20357 (Type). Type deposited in Herb. Crypt. Ind. Orient.

13. CINTRACTIA CARICIS (Pers.) Magnus, Verh. Bot. Ver. Prov. Brandenb. 37: 79. 1895.

Syn. *Uredo Caricis* Pers. Syn. Meth. Fung. p. 225. 1801.

On \*\**Carex cardiolepis* Nees, Sonamarg (Kashmir, 10,000 ft.), 25–7–1921, No. 6409; [this host is recorded as *Carex* sp. by Clinton and Zundel (1938)].

PERICLADIUM Pass. Nuovo Giorn. Bot. Ital. 7: 185. 1875.

Emend. Mundkur.

Syn. *Xylosorium* Zundel, Mycologia 31: 576. 1939.

Sori as oval pustules on stems, 2-4 locular, enclosed by a hard, coriaceous membrane rupturing irregularly at maturity, disclosing dark-brown, semi-agglutinated spore masses; spores at first as spore balls, disintegrating into single spores at maturity.

TYPE SPECIES: *Pericladium Grewiae* Passerini on *Grewia* (*mollis* Tues?) Abyssinia, leg. Beccari; the genus was placed by Passerini in the Uredinales but generic description has been emended and the genus transferred to Ustilaginaceae.

14. \*PERICLADIUM GREWIAE Pass.

Syn. *Ustilago Grewiae* (Pass.) Henn. Hedwigia 39: 75. 1900.

Petioles and branches covered by usually crowding, often coalescing, almost globose or sometimes angular, cinnamon brown, pustules, appearing like mustard seed, and enclosed by a coriaceous, hard, and woody covering; pustules 1-2 mm. in diameter, opening irregularly at apex forming a long crack, showing 2 or 3 locules, and a black powdery spore-mass. Spores nearly globose or ellipsoid, often somewhat angular, "buffy brown" (Ridgway), 5.6-8.6  $\mu$  in diameter with a mean of 7.8  $\mu$ ; epispore thick, smooth; germinating by means of a septate promycelium forming terminal and lateral sporidia.

On petioles and stem of\*\* *Grewia villosa* Willd. Kala Chitta Hills (Attock Dist.), April 1934, No. 13611 (FIG. 1).

15. SOROSPORIUM REILIANUM (Kuehn) McAlpine, Smuts of Australia, p. 181. 1900.

On *Sorghum halepense* Pers. Lower Sind Valley (Kashmir, 5500 ft.), Sept. 3, 1940.

TILLETIACEAE

16. \*UROCYSTIS COLCHICI (Schl.) Rab. Fungi Europei 396. 1861.

On \*\**Colchicum luteum* Baker, Abbottabad (N.W.F.P., 4000 ft.), April 1935, No. 14616.

17. UROCYSTIS STIPAE McAlpine, Smuts of Australia, p. 198. 1910.

On *Stipa sibirica* Lamk. Sonamarg, Sind valley (Kashmir, 9000 ft.), Aug. 31, 1940, No. 21286.

## 18. UROCYSTIS TRITICI Körn. Hedwigia 16: 33. 1877.

On *Triticum vulgare* Host, Topi Park, (Rawalpindi, Punjab.), Apr. 29, 1924.

## SUMMARY

Twenty-one collections of smuts made by Dr. R. R. Stewart and Mrs. I. D. Stewart in North Western India have been investigated. Of these *Ustilago Cordai*, *Ustilago reticulata*, *Cintractia Elynae*, *Pericladium Grewiae* and *Urocystis Colchici* are new records for India. Two smuts, *Sphacelotheca Stewartii* and *Cintractia Kohresiae*, are proposed as new species. The smut on *Grewia* which was placed in the genus *Ustilago* by Hennings has been restored back to the genus *Pericladium* proposed by Passerini for its reception and the genus itself has been transferred from the Uredinales to the Ustilaginales. Zundel's genus *Xylosorium* has been shown to be a synonym of *Pericladium* and his *Xylosorium Piperii* is proposed as *Pericladium Piperii* (Zundel).

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## AN UNDESCRIBED CORTICIUM WITH CONIDIA

C. L. SHEAR<sup>1</sup> AND ROSS W. DAVIDSON<sup>1</sup>

(WITH 2 FIGURES)

In March 1942 the senior author found on the bark of a decaying oak stump at Weikiwa Springs, Florida, a reddish-brown hyphomycete suggesting in general appearance forms that have been referred to *Ptychogaster* and *Ceriumyces*, some of which have been found associated with polypores (2). A microscopic examination showed an abundance of subglobose brown conidia. A careful examination about the margins and beneath the conidial layer revealed a thin, effuse, dingy gray hymenium that proved to be a species of *Corticium*. Single basidiospore cultures produced an abundant growth of the same conidial fungus that was associated with the *Corticium*. Microscopic examination shows that this conidial stage is very similar in character to some species that have been referred to *Sporotrichum* and *Rhinotrichum* rather than *Ptychogaster* or *Ceriumyces*.

Conidia have been described for four species of *Corticium*: *C. alutaceum* (Schröd.) Bres. (4), *C. roseo-pallens* Burt (1), *C. effuscatum* Cooke & Ellis (4, 5) and *C. vagum* Berk. & Curt. (3, p. 203; 7). Our fungus does not agree with any of these species either in the basidial or conidial form. A specimen was submitted to Dr. H. S. Jackson who is making a special study of *Corticium*. He reports that he knows of no species having such a conidial stage or agreeing with the basidial form. He suggests that if *Aleurodiscus* is to be treated as distinct from *Corticium* our plant might be referred to that genus. It seems best for the present to place it in *Corticium*. Therefore, it is described as a new species of that genus.

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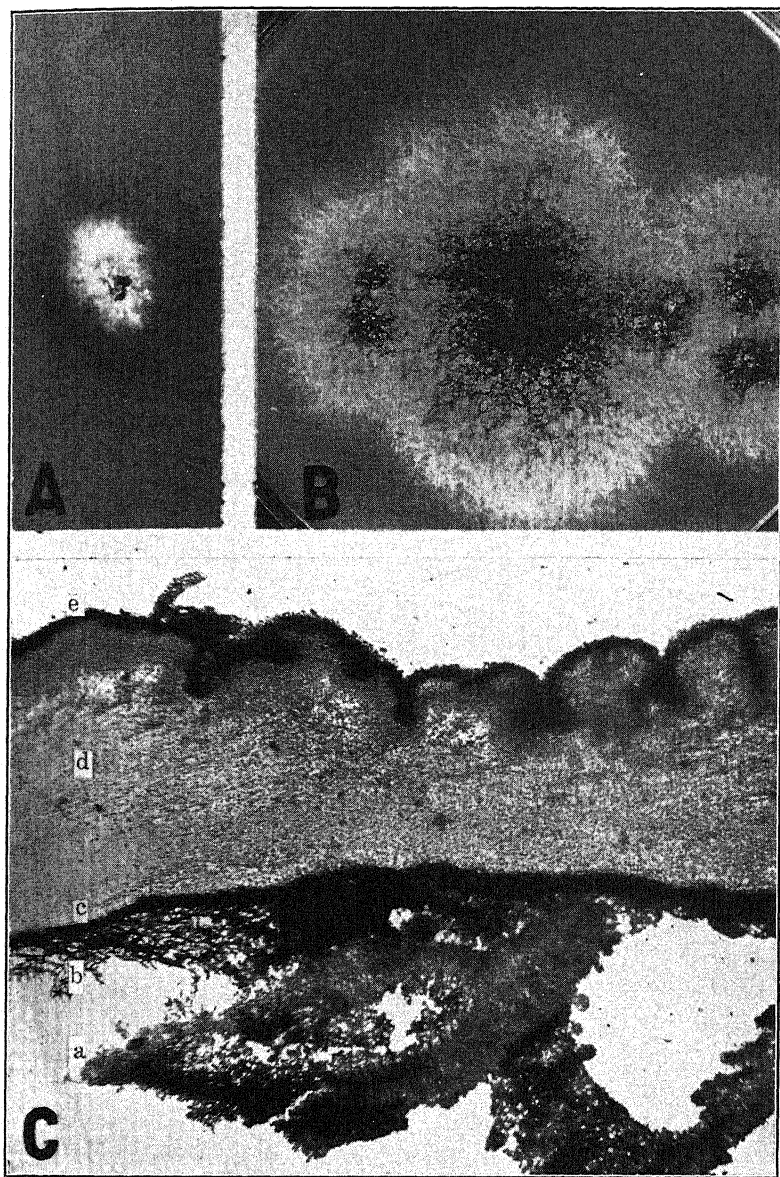


FIG. 1. *Corticium conigenum*. A and B, 8-day-old cultures. A, a slow growing haploid culture developed from a single basidiospore; B, a diploid culture showing dark mass of conidia in center of mat. C, photomicrograph of a section through basidial fructification: a, substratum; b, loose brown hyphae; c, compact narrow brown layer; d, dense thick layer of hyaline hyphae; e, hymenium.

**Corticium conigenum** sp. nov. (FIGS. 1, A-C; 2, A-F)

Fruiting layer effuse resupinate, several cm. broad, adhering to rough surface of bark, becoming dark gray to black or "fuscous"<sup>2</sup> to "black," surface pruinose, irregularly areolate; substance waxy, margin not conspicuous, varying in thickness from 300 to 700  $\mu$ , base composed of dark brown loosely interwoven hyphae and a thin compact layer of dark hyphae above which is a hyaline or slightly colored dense layer upon which appear areolate pulvinae that support the basidia; basidial layer dark at surface with numerous brown conidia and short segments of brown irregular hyphae (paraphyses?) and crystalline matter embedded; basidia 4-spored, hyaline, elongate; basidiospores hyaline, smooth, ovoid,  $6-7 \times 4-5 \mu$ .

Conidial layer loose floccose, powdery, "carob brown" or "burnt umber" (in culture when young light pink, soon becoming darker, "cameo brown" or "vinaceous-brown"); hyphae thin-walled, hyaline (in culture), much branched and with numerous septae and clamps, mycelium in pure cultures soon colored by masses of conidia; conidia brown, loosely catenulate, irregular or globose to oval in shape, slightly roughened, 4 to 6  $\mu$  in diameter, produced in great abundance on short terminal and lateral sporophores.

Fructificationes resupinatae, ceraceae, superficie pruinosa et irregulariter areolata, fuscae, 300-700  $\mu$  crassae, primum strato conidico vinaceo, floccoso, pulverulento tectae; basidiis 4-sporis; sporis ovoideis, glabris,  $6-7 \times 4-5 \mu$ ; conidiis globosis vel ovoideis, brunneis,  $4-6 \mu$  in diam.

On: stump of *Quercus* sp., Weikiwa Spa, Fla., March 10, 1942, C. L. Shear, No. 1405. Type specimen in the Mycological Collections of the Bureau of Plant Industry, Soils, and Agricultural Engineering.

## PURE CULTURE STUDIES

Conidia from the original specimen germinated within 16 hours when placed on cornmeal agar. All cultures from single conidia contained numerous clamp connections after two days growth and developed an abundance of conidia in 2 or 3 days.

Basidiospores were obtained by placing a small moistened section from the hymenium over a petri dish containing cornmeal agar. After about 18 hours in such a moist condition basidiospores were produced so abundantly that many cultures could

<sup>2</sup> Colors in quotation marks refer to Ridgway (6).

be obtained by slowly passing the segment of hymenium across the surface of the agar medium. The basidiospores germinated in about 6 hours after being deposited.

Single basidiospore cultures developed no clamp connections and grew only 1/2 to 2/3 as fast as the cultures from single conidia. They developed an abundance of conidia and in general appearance were similar to the cultures from conidia. Ten single basidiospore cultures were obtained and grown together in all possible

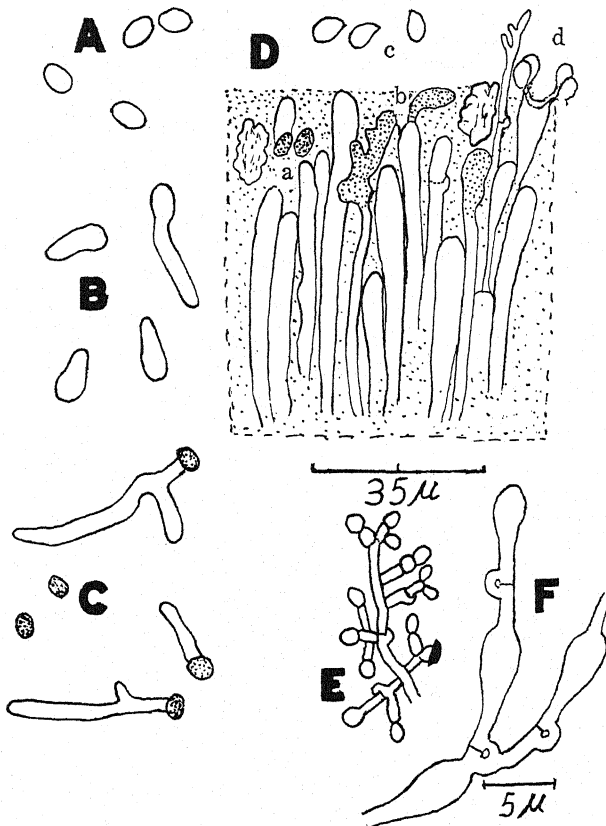


FIG. 2. A-E, *Corticium conigenum*. A and B, camera lucida outline drawing of basidiospores after 14 hours on cornmeal agar; C, germinating conidia from diploid mycelium; D, reconstructed section through hymenium, drawn with the aid of a camera lucida: a, embedded conidia; b, dark hyphae (paraphyses?); c, basidiospores; d, basidium; E, sketch of conidia developing on young hyphae; F, highly magnified hypha showing development of conidia.

combinations. They were found to consist of two sex strains—three of one strain and seven of the other (Table 1). Clamp connections developed where mycelium from any of the three came in contact with mycelium of any of the other seven. No clamps were formed from crosses within these two groups.

There was considerable difference in growth rate and conidial development of the ten single basidiospore cultures, but there

TABLE 1  
TEN SINGLE BASIDIOSPORE CULTURES OF *Corticium conigenum* SHOWING  
ALL POSSIBLE CROSSES

Culture numbers	1	2	3	4	5	6	7	8	9	10
1	— <sup>2</sup>	—	+	—	+	—	+	—	—	—
2	—	—	+	—	+	—	+	—	—	—
3	+	+	—	+	—	+	—	+	+	+
4	—	—	+	—	+	—	+	—	—	—
5	+	+	—	+	—	+	—	+	+	+
6	—	—	+	—	+	—	+	—	—	—
7	+	+	—	+	—	+	—	+	+	+
8	—	—	+	—	+	—	+	—	—	—
9	—	—	+	—	+	—	+	—	—	—
10	—	—	+	—	+	—	+	—	—	—

<sup>2</sup> — indicates no clamp connections formed and + indicates presence of clamp connections.

was no consistent visible difference between cultures from the two sex strains. It was impossible to determine the presence or absence of clamp connections except by a microscopic examination of mycelium from along the line where two cultures had grown together. Rate of growth for the single basidiospore cultures<sup>3</sup> was quite variable. The slowest growing one was No. 6 (FIG. 1, A), which made a diameter growth of 22 mm. in 7 days at room temperature of 24° C. and the fastest was No. 10 with 54 mm. diameter growth. Most of the cultures developed such an abundance of conidia that the mycelial mats soon became "vinaceous-brown" although the mycelium itself is white (FIG. 1, B).

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## TWO AMERICAN HARDWOOD SPECIES OF ENDOCONIDIOPHORA DESCRIBED AS NEW

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(WITH 2 FIGURES)

A fungus recorded as *Endoconidiophora coerulescens* Münch was found by Davidson (2) and Verrall (6) to be one of the most important fungi causing stain of hardwood logs and lumber in the South. During the earlier study (2) it was not observed on pine logs or lumber even where both pine and hardwood logs were handled by the same mill. Verrall (6) isolated it twice from pine wood but found it prevalent and important only on hardwoods. In Europe Münch (5) illustrated *E. coerulescens* on pine wood, and Lagerberg, Lundberg, and Melin (3) isolated it only from stained spruce and pine. A further reason for differentiating the pine- and spruce-inhabiting *E. coerulescens* of Europe from the fungus found on American hardwoods by Verrall and the author is the fact that the latter does not produce the amyloacetate odor, which is characteristic of *E. coerulescens* Münch (3).

Cultures of the European fungus were obtained from the Centraalbureau Voor Schimmelcultures and compared with isolates of the American fungus. These comparisons show that although the two are quite similar morphologically there are several consistent and significant differences. Therefore, the hardwood lumber fungus is described here as a new species.

The second species described in this paper produces a banana-oil odor but differs morphologically from *E. coerulescens* and other described species. It was isolated from chestnut oak bark.

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**Endoconidiophora virescens** sp. nov.<sup>2</sup> (FIG. 1, B and C)

Mycelium forming gray to black fluffy growth over sapwood on ends of recently cut logs and on surface of green lumber; perithecia abundant and conspicuous as black dots on surface of wood, forming in 4 to 7 days after infection; in culture black, 150–250  $\mu$  diameter frequently slightly higher than wide, covered with numerous long narrow black hyphae; beaks variable in length averaging 800  $\mu$  long, 35  $\mu$  wide at base to 14  $\mu$  at tip, smooth, black, with hyaline fringe of pointed hyphae around ostiole  $25 \times 1.5 \mu$ ; ascospores collecting in sticky white sphaerical mass at tip of beak, frequently arranged in bundles,  $5.5\text{--}7.5 \mu \times 1.7\text{--}2 \mu$ , slightly curved, hyaline; conidiophores brown, of two types, one long and enlarged slightly in middle but tapering to the hyaline to light brown tip, about 150  $\mu$  long by 5  $\mu$  at base to 2.2–3.5  $\mu$  at tip and bearing long cylindrical microconidia, other darker brown up to about 120  $\mu$  long enlarged slightly to the tip, 5–6  $\mu$  at base to 6.5  $\mu$  at tip and bearing chains of short barrel-shaped conidia; all conidia are formed endogenously, microconidia hyaline, cylindrical, in moniliform chains, variable in length,  $6\text{--}25 \mu \times 2\text{--}3 \mu$ , short barrel-shaped endoconidia  $5\text{--}9 \mu \times 5\text{--}6.5 \mu$  growth on malt agar rapid, about 45 mm. radial growth in 5 days, mycelium coarse, dark greenish gray, with musty penetrating odor.

On green sapwood of hardwood logs and lumber: *Liquidambar styraciflua* L., *Liriodendron tulipifera* L., *Nyssa aquatica* L., *Fagus grandifolia* Ehrh., *Magnolia* spp., and *Quercus* spp. common in Southern States from Virginia to Florida and Louisiana. Isolated twice from pine lumber (6). Type, For. Path. 94161, from *Liriodendron tulipifera*, in Myc. Coll. Bur. Plant Industry, Soils, and Agricultural Engineering.

Mycelium griseum vel atrum; perithecia in superficie ligni abundantia et conspicua, in culturis atra, 150–250  $\mu$  in diam., hyphis longis angustis atris tecta; rostra longitudine variabilia, plerumque 800  $\mu$  longa, basi 35  $\mu$  apice 14  $\mu$  crassa, levia, atra, e ciliis acuminatis hyalinis ostiolaribus 25  $\mu$  longis 1.5  $\mu$  latis fimbriata; ascosporae in massam glutinosum albam sphericam ad apicem rostri agglutinatae, saepe fasciculatae, 5.5–7.5  $\mu$  longae, 1.7–2  $\mu$  latae, subcurvatae, hyalinae; conidiophora brunnea, generum duorum, conidiis omnibus endogenis: altera longa, in medio subinflata, apicem hyalinum vel pallide brunneum versus attenuata, circa 150  $\mu$  longa, basi 5  $\mu$  apice 2.2–3.5  $\mu$  lata, microconidia hyalina cylindrica, 6–25  $\mu$  longa, 2–3  $\mu$  lata, in catenulis moniliformibus ferentia; altera obscuriore brunnea, usque 120  $\mu$  longa, apicem versus

<sup>2</sup> The Latin descriptions were prepared by Edith K. Cash, Assistant Mycologist, Division of Mycology and Disease Survey, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, United States Department of Agriculture.



leniter inflata, basi 5-6  $\mu$  apice 6.5  $\mu$  crassa, catenulas conidiorum breviorum dolabriformium 5-9  $\mu$  longorum 4-6.5  $\mu$  latorum ferentia.

In general growth and morphological features this fungus is very similar to *Endoconidiophora coerulescens* Münch, but the European species is reported by Lagerberg et al (3) to be a spruce fungus but growing also on pine. *E. coerulescens* forms a banana-oil (amyl-acetate) odor whereas the American hardwood

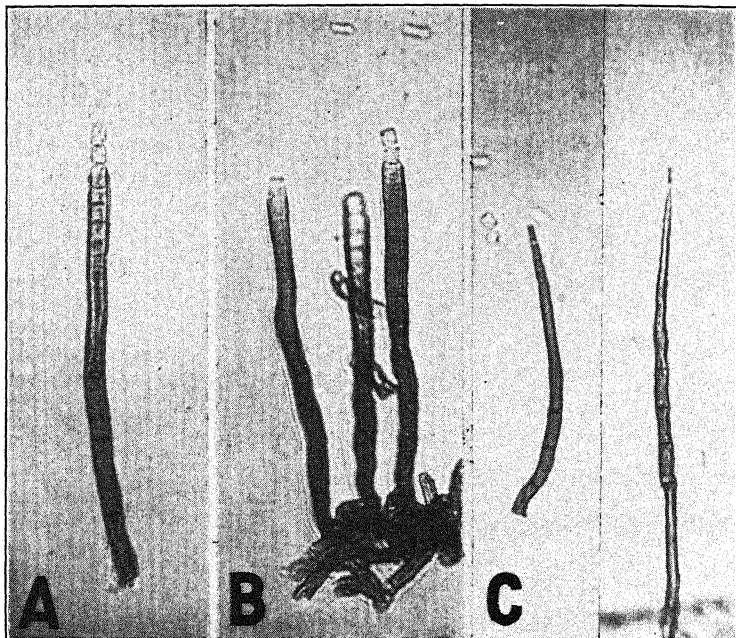


FIG. 1. A, typical conidiophore and endoconidia of *Endoconidiophora coerulescens* Münch; B, wide-mouthed conidiophores of *Endoconidiophora virescens*; C, small-mouthed conidiophores, with endoconidia attached, of *E. virescens*.

fungus develops a distinctive musty odor on lumber and in culture. There is also a difference in conidia and conidiophores. The conidiophores in the European fungus are stated to be 3.7 to 8.4  $\mu$  at the tip (FIG. 1, A) while those of *E. virescens* are of two types with the smaller diameter one 2.2 to 3.5  $\mu$  at the tip. None of the conidiophores described or illustrated by Lagerberg et al (3) and Münch (5) are of this small type. No conidiophores of the smaller tapering type were observed in the two *E. coerulescens*

cultures studied by the writer. The conidia of *E. coerulescens* are reported (3) to vary greatly and such variation is illustrated (3, figure 24, C). This same illustration also shows the two types of conidia, that is, long cylindrical and short barrel-shaped, but no measurements are given below  $4\ \mu$  and  $5\ \mu$  diameter by Münch (5), and Lagerberg et al (3) gives  $5\ \mu$  as the smallest for the cylindrical type. The cultures examined by the writer showed the same wide variation in conidial size but the smallest diameter observed was  $3\ \mu$  with an average of about  $4\ \mu$  for the cylindrical type, and as near as could be determined both cylindrical and barrel-shaped spores were produced from similar types of conidiophores.

According to the description of growth in pure culture (3) the American and European fungi are about the same. Both grow rapidly when first isolated and have a radially arranged, coarse, very dark gray-green mycelium. Older cultures of the American hardwood fungus are often quite variable in growth rate and may lose their ability to form perithecia. In such cultures the mycelial mat is usually of a lighter gray and fluffy type as contrasted with the radial gray-green growth of fresh cultures. Occasionally sectoring occurs and both types of growth are present, with perithecia confined mostly to the apparently normal segment. Several old cultures have failed to make a rapid radial growth. In such cases the mycelium is appressed and submerged and irregular in outline; conidia are abundant but perithecia are absent or develop only very slowly.

In older abnormal cultures odor may be absent or not very distinct.

The European cultures studied were slower growing and of a more velvety appressed type of mat, and perithecia developed very slowly. Conidia and conidiophores were exceedingly abundant. According to Lagerberg et al (3) this slower appressed growth is not normal for recent isolates. Odor was of the distinct banana-oil type.

***Endoconidiophora variospora* sp. nov. (FIG. 2, A-E)**

Forming a gray mold over surface of inner or cambium side of freshly peeled bark; perithecia not conspicuous, flask-shaped,

rather delicate, with base sphaerical to somewhat flattened and partially embedded, often collapsed,  $150\text{--}250\ \mu$  diam., light brown to black; beaks black,  $600\text{--}1200\ \mu$  long by  $25\text{--}35\ \mu$  thick at base to  $12\text{--}17\ \mu$  at ostiole, erect, sharp-pointed bristles around ostiole, ascospores collecting in a light brown sticky mass at tip of beak, hyaline, ovoid, with disk-shaped membrane on one side,  $4.5\text{--}6\ \mu \times 2\text{--}3.5\ \mu$ ; endoconidiophores light brown to hyaline, of two types, one tapering to small diameter at tip and bearing cylindrical endoconidia,  $50\text{--}80\ \mu \times 2.5\text{--}4\ \mu$ , the other light brown, several septate, short  $20\text{--}50\ \mu$  long, slightly enlarged to tip,  $4\text{--}5\ \mu$  diam. at base to  $5\text{--}7\ \mu$  at tip; endoconidia in chains, of two types, cylindrical, hyaline, to light brown,  $6\text{--}15\ \mu \times 2\text{--}4\ \mu$ , and short barrel-shaped,  $4\text{--}8\ \mu \times 4\text{--}6.5\ \mu$ , often becoming globose.

Cultures white, often developing gray to brown patches, conidiophores mostly longer,  $70\text{--}120\ \mu$ , often branched, tapering to tip, bearing cylindrical endoconidia, hyaline or light brown (black in mass); exogenous macroconidia abundant, borne on short narrow conidiophores, brown,  $10\text{--}14\ \mu \times 8\text{--}10\ \mu$ ; perithecia few or absent; 15 mm. radial growth in 5 days; odor similar to banana oil.

Perithecia inconspicua, lageniformia, tenella, basi rotundato vel subapplanato et partim immerso, saepe collapsa,  $150\text{--}250\ \mu$  in diam., ex pallide brunnea atra; rostra atra,  $600\text{--}1200\ \mu$  longa, basi  $25\text{--}35\ \mu$  apice  $12\text{--}17\ \mu$  crassa, ciliis rectis acuminatis ostiolaribus praedita; ascosporae in massam pallide brunneam mucosam ad apicem rostri agglutinatae, hyalinae, ovoideae, uno latere membrana disciformi ornatae,  $4.5\text{--}6\ \mu$  longae,  $2\text{--}3.5\ \mu$  latae; endoconidiophora pallide brunnea vel hyalina, generum duorum: altera ad apicem angustum attenuata,  $50\text{--}80\ \mu$  longa,  $2.5\text{--}4\ \mu$  lata, endoconidia cylindrica ferentia; altera pluriseptata, brevia,  $20\text{--}50\ \mu$  longa, basi  $4\text{--}5\ \mu$  apice  $5\text{--}7\ \mu$  crassa; endoconidia catenulata, dimorpha; altera cylindrica, hyalina usque pallide brunnea,  $6\text{--}15\ \mu$  longa,  $2\text{--}4\ \mu$  lata; altera breve dolabriformia,  $4\text{--}8\ \mu$  longa,  $4\text{--}6.5\ \mu$  lata, saepe globosa. In culturis conidiophora plerumque longiora,  $70\text{--}120\ \mu$ , saepe ramosa; macroconidia exogena abundantia, brunnea,  $10\text{--}14\ \mu$  longa,  $8\text{--}10\ \mu$  lata, in conidiophoris brevibus angustis oriunda; perithecia pauca vel nulla.

On cambium side of chestnut oak (*Quercus montana* Willd.) tanbark one week after it was removed from a living tree. Collected by Marvin E. Fowler near Moorefield, West Virginia, May 1943. Type 94257 in Myc. Coll. Bur. Plant Industry, Soils, and Agricultural Engineering.

This species is similar to *Endoconidiophora moniliformis* (Hedg.) Davidson (2) in ascospore character and in odor but has perithecial and conidial differences. The large brown macroconidia produced abundantly in cultures are similar to those of *Chalarop-*

*sis thielavioides* Peyronel (4) and *Ceratostomella* (*Endoconidiophora*) *radicicola* Bliss (1). It is most closely related to the latter species but differs in shape and size of ascospores, growth

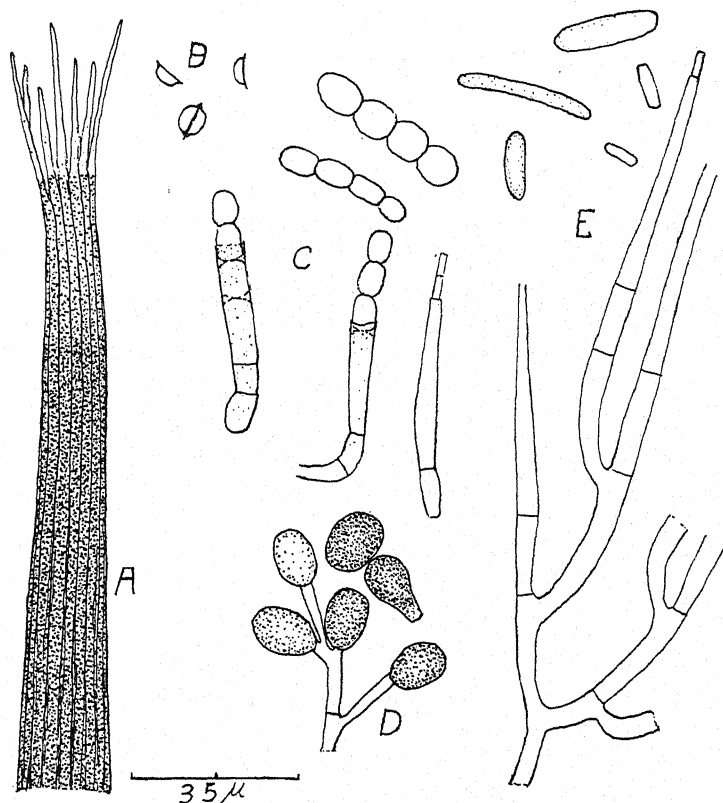


FIG. 2. A-E, *Endoconidiophora variopora*. A, tip of perithecial beak; B, ascospores; C, conidiophores and endoconidia from chestnut bark; D, exogenous macroconidia developed in culture; E, conidiophores and endoconidia from a culture.

rate, and color of mycelium. The short broad type of endoconidia were not described for *C. radicicola* and the type of odor produced was not recorded.

#### SUMMARY

The common American hardwood staining species of *Endoconidiophora* previously referred to *E. coerulescens* Münch, a conifer fungus, is shown to be a distinct species and described as

*E. virescens*. Another related species causing gray mold on chestnut oak tanbark is described under the name *E. variospora*.

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## NOTES AND BRIEF ARTICLES

### FUNGI FOR PENICILLIN PRODUCTION

A project is being organized at the University of Minnesota Agricultural Experiment Station, Division of Plant Pathology on Botany, to survey *Penicillia* belonging to the *Penicillium notatum* group and also species of *Aspergillus* for the production of penicillin. The project is under the supervision of Dr. E. C. Stakman. Cultures of organisms are desired, and individuals are requested to forward isolations of the groups of fungi mentioned to the laboratory indicated. Isolations known to produce penicillin are especially desired.

Individuals who wish to survey other fungi for penicillin activity can obtain directions for a standard technique from the United States Department of Agriculture, Regional Laboratory at Peoria, Illinois.—ALBERT L. ELDER, War Production Board, Coördinator of Penicillin Program.

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### ODONTIA ARCHERI (BERK.) WAKEFIELD

This large and handsome resupinate was collected more than once during January and February, 1944, on the sides of corticated logs of loblolly pine in low, dense woods near Gainesville, Fla. Being entirely new to me, I sent it to Dr. Linder, at Harvard, for determination. "I am glad," he said, "to have this specimen since it is the first collection of the species that we have from the United States, and furthermore it is better developed than the other ones we have, which came from the tropics." The hymenium is flavous when young, becoming melleous when mature, and the colors are well preserved in dried specimens.—W. A. MURRILL.

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### SIR EDWIN BUTLER, 1874-1943

A recent letter from Professor F. T. Brooks of Cambridge University tells of the death in April, 1943, of Sir Edwin Butler, Kt., C.M.G., C.I.E., F.R.S., D.Sc., LL.D., M.B.

To the student of Aquatic Phycomycetes Sir Edwin's name is forever linked with that classic, "An Account of the Genus *Pythium* and some Chytridiaceae," as well as with other outstanding papers in the group, one establishing the remarkable genus *Allomyces*. To one who also had the high privilege of knowing and of having frequent contacts with him in his capacity as Director of the Imperial Mycological Institute at Kew, and as Lowell Lecturer in Boston in 1932, his name is linked, as well, with a genial, cordial and hospitable Irish gentleman.—F. K. SPARROW, JR.

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Corrections in the article "The genera *Trechispora* and *Galzinia* (Thelephoraceae)," published in *Mycologia* 36: 70–103. 1944.

Page 70, 1st paragraph, line 8: a period should be inserted after "*Brinkmanni*."

p. 77, l. 7: for "p. 73" read "p. 99"; in the footnote (l. 23) for "*Episthele*" read "*Epithele*."

p. 87, l. 27: for "*I. coronifera*" read "*T. coronifera*."

p. 99, l. 14: for "p. 80" read "p. 77."

DONALD P. ROGERS

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#### A NEW RUSSULA SPORE

On a February afternoon I was picking my way through small shrubs in a piece of open flatwoods and admiring the first flowers of *Viola septemloba* when I happened upon a small reddish russula with pink stem and pure-white gills. At first I was inclined to ignore it in favor of the handsome violets but picked it on principle and took it to my desk at the University. Little did I realize what a surprise was in store for me. On casually examining the spores under a microscope I decided I had a parasite, or something, and began to look around for the real spores. Then I made a good mount and stained it, and there were these same peculiar spores on basidia on a bit of the gill!

*Russula* spores as a rule, as mycologists very well know, are rounded, more or less aculeate, and amyloid. Beardslee discovered a notable exception in his *R. heterospora* with smooth, oblong spores, but this one species has remained so far as I know

the only exception to the general rule in this large genus. This new type I have just found is very different from the one Beardslee described. In shape and size the spores are similar to those found in many species of *Tricholoma*, being narrow, inequilateral, and obliquely apiculate at the base. But they are amyloid and characteristically aculeate. Who would have expected an innocent-looking little red russula to turn out to be such a brazen nonconformist!

***Russula novispora* sp. nov.**

Pileo convexo-subdepresso, 3 cm. lato, glabro, roseo, non grato; lamellis adnatis, latis, albis; sporis subellipsoideis, aculeatis, albis,  $8 \times 5 \mu$ ; cystidiis fusiformibus; stipite glabro, subincarnato,  $1.5 \times 0.6-0.8$  cm.

Pileus convex to slightly depressed, solitary, 3 cm. broad; surface slightly viscid, smooth, glabrous, deep-roseous, darker at the center, margin even, entire; context white, unchanging, 5 mm. thick near the disk, odorless, very astringent and slightly acid; lamellae adnate, few inserted, not forked, ventricose, rather broad, close, entire, white; spores chalk-white in mass, elongate subellipsoid, inequilateral, obliquely apiculate, sparsely but distinctly echinulate, about  $8 \times 5 \mu$ ; sterile cells abundant, sharp, hyaline, projecting  $15-25 \mu$ ; stipe tapering downward, smooth, glabrous, pale-incarnate, unchanging,  $1.5 \times 0.6-0.8$  cm.

Type collected by W. A. Murrill in rather moist open slash-pine flatwoods just east of Gainesville, Fla., Feb. 11, 1944 (*F 17994*). Distinguished at once by its unusual spores, of a type hitherto unknown to me in the genus. They are shaped like those of many species of *Melanoleuca*, *M. equestris*, for example. The dried cap resembles in color the dark form of *R. amethystina* Quél. but is not umbonate.—W. A. MURRILL.

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RESISTANT SPORANGIA ON SEXUAL PLANTS OF  
*ALLOMYCES ARBUSCULUS*

It was on December 15, 1933, that the writer first noticed resistant sporangia on sexual plants. In April, 1934, Emerson "discovered numerous resistant sporangia borne on sexual plants of *A. arbusculus* var. *minor*—. Since that time they have frequently been found (by Emerson)—in agar as well as older water cultures of a majority of the isolates of both *A. arbusculus* and



*A. javanicus*." <sup>1</sup> . . . "Sörgel (1937) also observed the formation of resistant sporangia on hyphae bearing gametangia in the strains of *A. arbusculus* which he studied." <sup>1</sup>

"Hatch (1935) said that sexual mycelia could be derived from isolations of zoöspores from resting (resistant) sporangia formed on sexual mycelia, but he gave no experimental evidence in support of this statement." <sup>1</sup>

The evidence to substantiate my 1935 statement, referred to in the paragraph above, is submitted herewith.

Camera lucida drawings, made in December 1933, at the time of the writer's original observations, show the various positions taken by the resistant sporangia on the plant. Sometimes the resistant sporangia were subtended by male gametangia. In other instances the resistant sporangia appeared on sympodial branches that grew around couplets of male and female gametangia. The resistant sporangia sometimes terminated the growth of the hypha, but in most cases the growth of the hypha was continued past the resistant sporangia by sympodial branching. On certain hyphae these sympodial branches again produced pairs or chains of gametangia.

Upon the plant on which this initial study was made the resistant sporangia were numerous—almost as numerous as upon the asexual plant. The plant in question was grown on a maltose-peptone agar plate, the resistant sporangia appearing late in the history of the culture as the agar began to dry.

The nature of the products derived from these resistant sporangia was determined by drying the resistant sporangia 18 days and inoculating them into sterile distilled water to which hemp seed had been added. The zoöspores from these resistant sporangia germinated to form sexual plants which were normal in all observable respects. Three days after the resistant sporangia had been introduced into the baited water cultures the new plants could be definitely identified as sexual because of the characteristic pigmentation of the male gametangia. While no camera lucida drawings were made of these plants, camera lucida drawings were made of certain sexual plants that had developed from zoöspores that had been discharged from

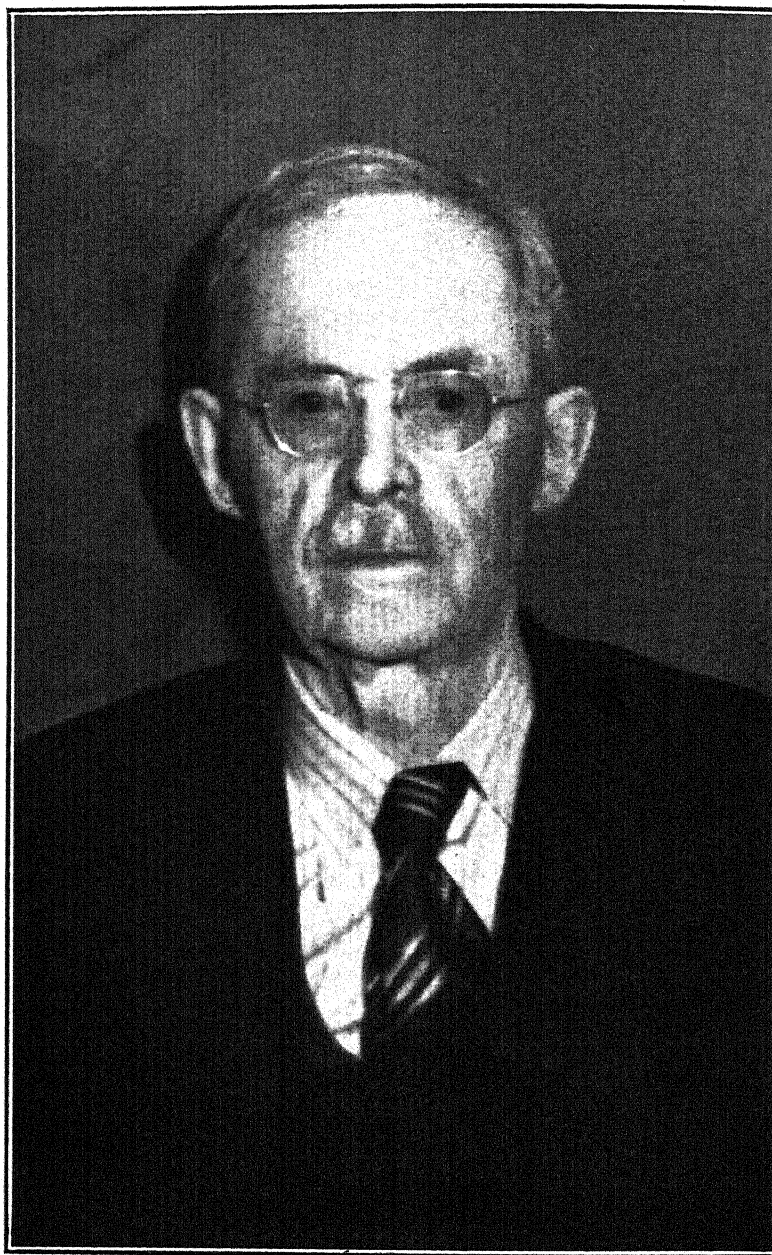
<sup>1</sup> Emerson, 1941.

one of the resistant sporangia on the original plant—the plant on which the resistant sporangia were first observed. The resistant sporangium in question had dehisced in the agar, producing zoöspores and in turn sexual plants.

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WINSLOW R. HATCH



WILLIAM POLLOCK FRASER.

# MYCOLOGIA

OFFICIAL ORGAN OF THE MYCOLOGICAL SOCIETY OF AMERICA

VOL. XXXVI JULY-AUGUST, 1944

No. 4

## WILLIAM POLLOCK FRASER, 1867-1943

T. C. VANTERPOOL

(WITH 1 FIGURE)

On November 23, 1943, the ranks of Canadian botanists, and especially those of mycologists and plant pathologists, lost a prominent figure through the death of William Pollock Fraser, Emeritus Professor of Biology at the University of Saskatchewan. He had been suffering from heart trouble for some time, but was fortunately able to visit his herbarium until a few days before his death. He is survived by his widow, the former Alice McRae, who through their long years of comradeship frequently accompanied him on his collecting trips, and in later years was a constant helper in his herbarium.

Dr. Fraser was born on a farm in Pictou County, Nova Scotia. Through the untimely death of his father, the main burden of running the farm fell to him when still a young man. His early education was obtained at a typical country school, and it was not until his twenty-first year, when the family farm was sold, that he was able to attend High School, first at New Glasgow and later at Pictou Academy, from which he matriculated in 1896. Shortly afterwards he obtained a teacher's license in science and an agricultural diploma of Nova Scotia, and began his career as a school teacher. In 1899 he entered Dalhousie University where he pursued his studies for two years. Then followed a period in which he taught, first as Principal at Westville High School, and later as Instructor in Natural Science at Pictou Academy. He was already an inveterate plant collector and made good use of his own

[MYCOLOGIA for May-June (36: 223-311) was issued June 7, 1944.]

specimens for class demonstrations. To continue his training in botanical science he entered Cornell University in 1905, and in 1906 graduated with the B.A. degree. It was at Cornell that he came under the stimulating influence of Professor G. F. Atkinson, whom he held in very high esteem. The forays which he made among the glens at Ithaca in company with Professor Atkinson lent full play to his ingrained love of collecting and were, indeed, some of the most memorable of his life. On leaving Cornell he returned to his teaching position at Pictou Academy. About this time he began a correspondence and an exchange of specimens of rusts with Dr. J. C. Arthur at Purdue University, Indiana, which continued for many years.

He published his first scientific paper, The Erysiphaceae of Nova Scotia, in 1909. Then began a series of papers on cultures of heteroecious rusts. These mycological contributions at first exceeded his purely pathological ones, but the relationship was later reversed, due to circumstance of position and not wholly to any inherent preference for pathology. His early studies on the rusts culminated with the publication of a monograph on "The Rusts of Nova Scotia" in 1913. It was largely for these studies that he was granted the M.A. degree from Dalhousie University in 1910. "The Uredinales of the Prairie Provinces of Western Canada" appeared in 1925 with I. L. Connors as co-author. Several mycological papers on the complex host relations of the crown rust, *Puccinia coronata* Corda, concluded the series of contributions on heteroecious rusts. His final publications dealt with plant taxonomy.

In January 1912, he left his native province to become Lecturer in Biology at Macdonald College, McGill University. As his publications at this time show, he was concerning himself more with economic plant diseases. He spent part of the summer of 1915 studying diseases of the apple in the Annapolis Valley for the Nova Scotia Department of Agriculture.

Following the severe wheat rust epidemic on the Prairie Provinces in 1916, at the request of the Dominion Government he spent the two following summers in Western Canada surveying the rust situation and studying environmental and other causes which led to the 1916 outbreak. In 1919 he was appointed Officer-in-charge

of the new Dominion Laboratory of Plant Pathology established at Saskatoon in coöperation with the University of Saskatchewan. In 1925 he left the Government service to become full-time Professor of Biology, which position he held until his retirement from active teaching in 1937.

Dr. Fraser early realized that certain fundamental information on the cereal rust problem had to be ascertained before much progress in controlling these diseases could be made. Thus, during the first years at the Saskatoon Laboratory attention was given to such matters as field surveys, a study of the conditions that influence the spread and development of rust, native grass hosts, and the part, if any, they played in hibernation, the whole problem of the origin of outbreaks, and the extermination of the common barberry. These earlier projects were soon followed by studies on varietal resistance to stem rust and on the prevalence of physiologic races of *Puccinia graminis Tritici*. Dr. Fraser rapidly obtained an all-round picture of the diseases affecting cereal crops on the prairies and was soon able to initiate research on important diseases other than the rusts. The *Helminthosporium* diseases of wheat and barley, smut of slender wheat grass, *Fusarium* scab on wheat, and control of the cereal smuts, were among the earlier projects; and take-all of wheat (*Ophiobolus graminis*) was added later. He was proud of the fact that early steps had been taken which resulted in the eradication of the common barberry from the Canadian Prairies. In 1922, in the Report of the Dominion Botanist, he advocated that the planting and importation of the buckthorn (*Rhamnus cathartica* L.) should be forbidden. "The buckthorns that have already been planted should be eradicated," indicates that he believed the buckthorn should go the way of the barberry. Unfortunately the opportunity was allowed to pass. As head of the first laboratory of Plant Pathology in Western Canada, he may be said to have laid the foundation for plant disease work generally, and in particular for research work on the cereal rusts.

On his retirement from academic duties in 1937, the University of Saskatchewan bestowed on him an honorary LL.D. in recognition of his contributions to the solution of the cereal rust problem and of his outstanding work on the native flora of Saskatchewan, and also made him Emeritus Professor of Biology. He,

however, continued to have charge of the University phanerogamic herbarium which he planned to reorganize and extend. This proved to be a happy arrangement for the University and for him. He succeeded in building up an unsurpassed herbarium of wild plants of Saskatchewan. As a token of appreciation for this endeavour, the University authorities have designated this plant collection as "The W. P. Fraser Herbarium." Unfortunately he was prevented, partly by his failing health and partly because of the lack of trained assistants during the late depression and war years, from organizing the cryptogamic herbarium. The present fungus collection is made up largely of his own specimens and forms an excellent nucleus for a Mycological Herbarium of prairie forms.

Dr. Fraser was a Fellow of the American Association for the Advancement of Science, and an honorary member of the Canadian Phytopathological Society, of which he was Vice-President 1929-1931 and President 1931-1933. He was also a member of the Mycological Society of America and the American Phytopathological Society. He served for many years as a member of the Associate Committee on Field Crop Diseases of the National Research Council and the Dominion Department of Agriculture.

He was a man of sterling integrity, with a high ethical and moral sense which demanded strong qualities of will and character. His extreme modesty and reserved, unassuming manner—he hated pretense of any kind—tended to conceal much from his friends and associates. Yet he possessed a characteristically dry sense of humor which was often indulged in when least expected, thus making it all the more memorable. All who knew him well were won by the nobleness of his motives.

Being an untiring collector—his holidays were planned with collecting in mind—he always had a wealth of demonstration material, both dried and preserved, for his laboratory classes which he personally supervised, and made sure that the students' laboratory studies were from specimens examined both macroscopically and microscopically, and not from drawings in textbooks. As a teacher he was at his best with advanced and graduate students, who revered him as a man and for the straight-forward presentation of his material, which was based on a sound, first-hand knowledge of his subject. Upon students and associates alike his quiet enthu-

siasm and his diligent devotion to the task in hand made lasting impressions. He always presented a memorable picture when returning from collecting forays with his large vasculum over his shoulder and both hands full of specimens. One likes to remember him also among stacks of drying paper, wooden presses and drying boxes—bought and home-made—with rocks and scrap iron for weights. He had a rare knowledge of wild plants and of plant diseases in the field, supplemented by a keen ecological sense. Not only did taxonomists, mycologists and plant pathologists find his help invaluable, but also soils men in their studies of vegetation in relation to soil types.

Among specialists in his field he will be remembered chiefly for his studies on heteroecious rusts, as one of the pioneer mycologists and plant pathologists of Canada, and as an authority on the native flora of Saskatchewan. But, as a close associate has said, "his greatest influence will be through the effects of his own character on his students and colleagues."

UNIV. OF SASKATCHEWAN,  
SASKATOON, SASKATCHEWAN.



# STUDIES IN THE GASTEROMYCETES

## X. SEVEN NEW SPECIES OF TYLOSTOMA

W. H. LONG

(WITH 7 FIGURES)

The examination of several hundred specimens of *Tylostoma* has indicated that external characters are very characteristic and therefore important, although many of them heretofore have been only casually mentioned and some have never been noted at all. This has been especially true in describing species, where the characters usually stressed have been the spore markings and capillitium, the mouth characters, and in a general way the size of the plant.

*Sporophore*: The relative size of the plants is an important specific character, for instance, plants 1-3 cm. tall do not make plants 6-8 cm. tall and vice versa. Of course there may be an occasional giant or miniature specimen in a given collection, but such plants do not determine the normal size of the species.

*Sporocarp*: The tightness or looseness of the attachment of the sporocarp to the stipe apex is a fixed and important character. The sporocarp may be firmly or loosely attached to the stipe apex (FIG. 2), so that it easily becomes disjointed. The great majority of the species belong to the firmly attached type. I find this tightness or looseness a very important character and one that is constant for a given species.

*Exoperidium*: This consists of 2 distinct zones, a basal band or peridial sheath enclosing the base of the endoperidium (FIGS. 1, 2) and the remaining portion or the exoperidium proper. This *peridial sheath* is a tough layer of agglutinated hyphae and sand, firmly attached to the base of the endoperidium and differing in texture and composition from the exoperidium proper, which constitutes most of the exoperidium.

The exoperidium proper may occur in one of 3 different types

of structure; (1) a granular type consisting of hyphae and sand, (2) a semi-membranous structure, and (3) a permanently membranous exoperidium. All three types have an outer covering of sand loosely held together by mycelial threads when freshly emerged. The *granular exoperidium* has its inner layer composed of flocci which do not form a definite membrane, but produce an amorphous layer of hyphae attached rather firmly to the endoperidium and usually deciduous under weathering. This is the usual type of exoperidium found on most species of *Tylostoma* (FIG. 2). The *semimembranous* type has as its inner layer a very thin weak membrane, which, when dry, becomes friable, granular and usually early and completely deciduous, peeling off in flakes soon after emerging and leaving the endoperidium perfectly smooth (FIGS. 1, 7). The *membranous* type has as the inner layer of the exoperidium a permanent membrane (FIG. 4) and is completely deciduous, falling away in pieces and finally leaving the endoperidium perfectly smooth. This type is very rare.

*Endoperidium*: The color of the endoperidium varies for a given species. It may be white when fresh, or shades of drab, gray, and brown, many of these colors usually becoming lighter with age and weathering. As a rule each species retains its characteristic color for several months, although, of course, this color may be obscured by the fragments of the exoperidium persisting, or by adhering dirt. All endoperidia tend to whiten under prolonged weathering, and this is especially true of the gray and drab colored ones.

*Mouth*: Mouth characters present a definite basis for a primary dividing of the genus and may occur in three general types, (a) tubular, (b) fibrillose, and (c) indefinite. The first type may be a well marked tube, a short tube, or a very short or slightly projecting tubular rim. The fibrillose type may be divided into 2 subtypes, (a) those having a raised heavy fibrillose mat or border around the mouth opening and (b) those having a few fibrils around the opening even before weathering. This type of mouth is not uncommon in the arid regions of my territory. These fibrils often wear off under weathering, leaving the mouth indefinite and naked. The third type of mouth is neither tubular nor fibrillose, but simply consists of an indefinite lacerate aperture. Some plants

may have several mouths on the same sporocarp, usually of the short tubular type and often irregular in shape. I have seen but two plants with more than one mouth of the fibrillose type.

*Stipe*: The cortex or outer layer of the stipe or stem varies in color from white to shades of brown. This color as a rule deepens with age and weathering, in contrast to the color of the heads which tends to fade with age. Many stipes are white as they emerge from the soil, but may change to shades of brown in a short time. The normal color of such stipes when mature would then be classed as brown, while there are other species which have brown stipes from their first emergence. The cortex usually is not shed as claimed by some writers, but remains unless extreme weathering or handling causes it to break away. The stipes of all species of *Tylostoma* seen are white within and hollow, a characteristic of the genus.

The characters of the base of the stipe are very distinctive and can be divided into the following sections: (1) base radicating, not volvate or bulbous, (2) base bulbous with adhering hyphae and sand or even a solid woody bulb, (3) base bulbous and also radicating, (4) base volvate and not radicating, (5) base volvate and radicating, (6) bulbous and not radicating or a combination of 2 or more of these characters. Many of the basal characters are lost in collecting or in subsequent handling in the herbarium.

*Volva*: The volva is a term applied to certain species of *Tylostoma* which have a volvoid cup in which the stipe is seated. The genus does not have a universal veil, hence this is not a true volva. In addition several species have an inner or secondary volva consisting of the membranous lacerate remains of the upper part of the outer stipe cortex, which were torn loose from beneath the head on elongation and left as a collar around the base of the stipe inside the usual volva.

I am following Saccardo, Hollós, Coker and Couch and other prominent scientists in correctly spelling the generic name, *Tylostoma*. There is no legitimate Greek-English derivative, *Tulos-toma*, the word is plainly a mis-spelling and under the International Rules of Botanical Nomenclature, it is permissible to correct typographic or orthographic errors.

**Tylostoma cretaceum** sp. nov.

*Sporocarp* ovato, subglobose usque depresso-globose, 7–10 mm. alto, 10–20 mm. lato. *Exoperidio* semimembranaceo, toto secedenti. *Endoperidio* cretaceo albido. *Ore* parum fibrilloso. Stipite 3–10 cm. alto, tenui, 1–3 mm. crasso ad basim, pseudovolvatum, radicatum. *Sporis* subglobosis, 3.5–5.6  $\mu$ .

*Sporophore* consisting of sporocarp, stipe, volva and radicating base, originating 2–8 cm. below the surface of the soil. *Sporocarp* ovate, subglobose to depressed-globose, 7–12 mm. high by 10–20 mm. in diameter, firmly attached to the stem apex. *Exoperidium* semi-membranous, very thin, coated with sand, becoming friable and granular when dry, "mikado brown to russet" (Ridgway) when fresh, peeling off in flakes just as, or soon after emerging from the soil, usually before the mouth opens, drying to a thin granular layer of flocci and sand if the shedding is delayed, completely deciduous; *peridial sheath* non-deciduous, a narrow band 2–3 mm. wide with agglutinated hyphae and soil. *Endoperidium* chalky white when fresh (FIG. 1), often becoming dingy white in age, sometimes "tilleul buff," when exoperidium is slow in shedding, membranous, tough, smooth, often pitted. *Mouth* raised with a scanty fibrillose, granular, pitted peristome, circular, elliptic or irregular, with erumpent lacerate edges in age, stomatal fissures often extending to base of sporocarp under extreme weathering. *Stipe* slender, 3–4 cm. tall, usually attenuate downward, straight or curved, rarely uniform, 4–6 mm. thick at spore sac, 1–3 mm. thick at base, smooth, or sometimes minutely scurfy, becoming smooth in age, rarely striate, white. *Volva* double, outer layer formed from the mycelial pad at base of stipe, 6–10 mm. across by 4–6 mm. high, friable, margin incurved, rounded and even, composed of 2 layers (1) a thick gray, granular outer coat of agglutinated hyphae and sand, and (2) a cream-colored mycelial inner wall; surrounding the stipe inside the volva are the lacerate membranous fragments of the upper part of the stipe cortex 4–10 mm. high which were torn loose from beneath the spore sac on elongation. *Base of stipe* strongly radicating, roots 1–5 cm. long, 2–6 mm. thick where joined to volva, often branching, similar in context to volva, usually brittle when dry, hence easily broken in handling. *Gleba*, cinnamon brown to dark ferruginous. *Capillitium* colored, fulvous to brown, 3–7  $\mu$  thick, branched, flaccid, often flattened by collapsing then ribbon-like. Some breaking into short pieces, septa rare, not swollen. *Spores* subglobose to oval, mainly oval, some 1-guttulate, 4–4.5  $\mu$  in diameter for globose, and 3.5–4.2  $\times$  4.2–5.6  $\mu$  for the oval spores. *Epispore* fulvous to dark brown, smooth.

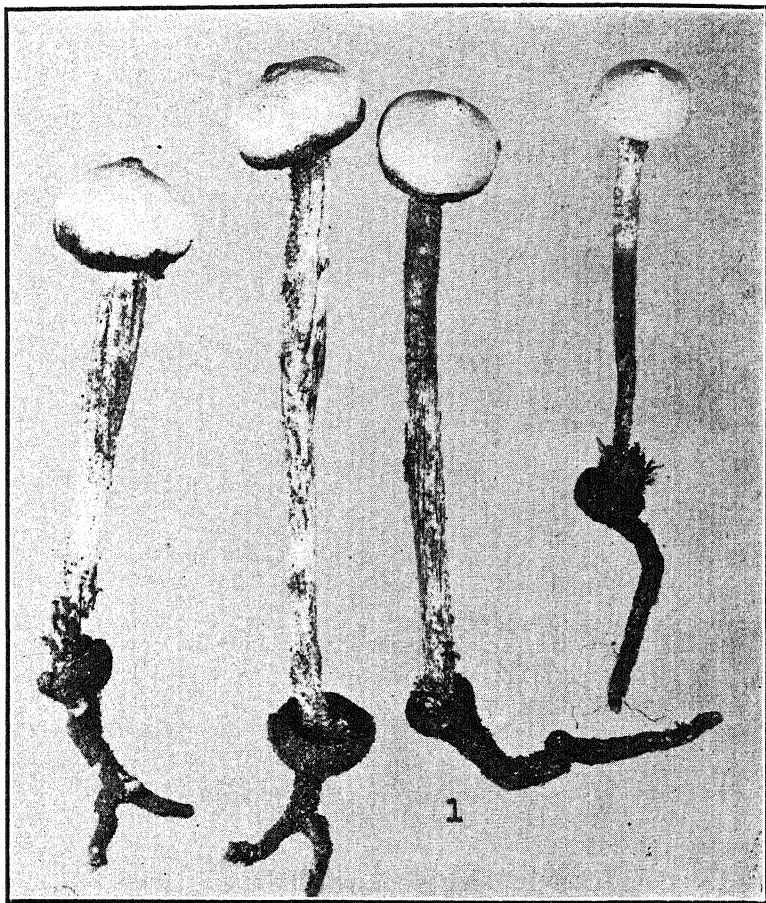


FIG. 1. *Tylostoma cretaceum*, fresh plants just emerged,  $\times 1$ .

HABITAT: Solitary in open, unshaded deep sandy soil and in gypsum flats.

DISTRIBUTION:

NEW MEXICO. SANDOVAL COUNTY, 3 miles south of the Bernalillo bridge on west side of Rio Grande River, elevation 5100 feet, *W. H. Long*, July 17, 1941—26 plants 9452; 2 miles south of Bernalillo on highway 85, *W. H. Long*, July 12, 1941—13 plants 9440, August 24, 1941—15 plants 9172. BERNALILLO COUNTY, on mesa near old golf links, elevation 5000 feet, *W. H. Long*, July

8, 1920—1 plant 5190; near old gun club grounds 8 miles south of Albuquerque, elevation 4900 feet, *W. H. Long*, May 30, 1917—4 plants 8993; west side of Rio Grande River in foothills near volcanoes, elevation 5200 feet, *W. H. Long*, June 23, 1917—1 plant 8874; 10 miles west of Albuquerque on lower mesa, elevation 5100 feet, *W. H. Long*, October 4, 1916—7 plants 5683; west side of Rio Grande River, 2 miles south of Alameda bridge, elevation 5000 feet, *W. H. Long*, October 11, 1918—69 plants 8387, May 7, 1939—83 plants 8396, March 17, 1940—2 plants 9150; *W. H. Long and David J. Stouffer*, December 8, 1940—104 plants 9197; *W. H. Long*, May 7, 1941—188 plants 9302 (Type), July 17, 1941—22 plants 9454, May 25, 1942—48 plants 10255; 4 miles north of Albuquerque on Highway 85, elevation 5000 feet, *W. H. Long*, May 31, 1941—198 plants 9338, June 10, 1941—53 plants 9352, June 25, 1941—123 plants 9364, October 7, 1941—40 plants 9820, May 7, 1942—45 plants 10245; east of Kirtland Field, army airport at Albuquerque, elevation 5000 feet, *W. H. Long*, November 27, 1941—17 plants 9909, November 28, 1941—106 plants 9915, January 19, 1942—1 plant 9979; southeast of Kirtland Field, elevation 4950 feet, *W. H. Long*, August 30, 1941—69 plants 9483, September 1, 1942—43 plants 9487. VALENCIA COUNTY, east of Rio Grande River, 4 miles below Belen bridge, elevation 4785 feet, *W. H. Long*, September 24, 1941—45 plants 9720, December 6, 1941—29 plants 9924. DONA ANA COUNTY, Jornada Experimental Range, elevation 4150 feet, *W. H. Long*, October 2, 1939—1 plant 9192; *W. H. Long and David J. Stouffer*, September 8, 1941—5 plants 9597. OTERO COUNTY, White Sands National Monument, in gypsum flats, elevation 4250 feet, *E. Ray Schaeffner*, August 30, 1941—3 plants 9687, 7 plants 9954, 4 plants 9955, 9 plants 9957; *W. H. Long*, April 22, 1942—24 plants 10110; making a total of 1405 plants collected to date.

The above distribution shows that *Tylostoma cretaceum* ranges from near Bernalillo, New Mexico, down the Rio Grande Valley to the Jornada Experimental Range some 28 miles east of Las Cruces, New Mexico, thence east to White Sands National Monument.

The plants growing west of the Rio Grande River were usually in open deep sand among *Parosela* and *Gutierrezia* vegetation in

the foothills near the river; on the east side of the river these plants were growing on small wind-formed sand dunes. Those collected below Belen were on sand-clay ridges in sage brush (*Artemisia*) areas, and showed a very pronounced peridial sheath around the base of the spore sac. The Jornada plants were growing in a sandy hard pan soil in open areas between the mesquite-sandhill dunes. The plants in the White Sands National Monument were in flats surrounded by gypsum dunes in open naked areas.

Many belated plants appearing in the fall of the year were flat-topped, with mouths not open or very slow to open. Such plants often had stipes uniform in diameter when fresh but tapering toward the base after weathering. All old weathered plants found always had strongly attenuate stipes.

The stipes are so firmly attached to the endoperidia that none were found which had become detached, even though the endoperidia might be so old and weathered that they had split open and the gleba of each had disappeared. Stipes of plants collected as they emerged became striate on drying from shrinkage, although mature plants in the field rarely showed any striae.

The fibrils of the peristome appear granular and pitted from the impress of the sandy exoperidium. This character is often not apparent to the naked eye but can easily be seen with a hand lens.

*Tylostoma cretaceum* has three outstanding characters, the chalky white endoperidium, the volva-like cup at the base of the stem and the large roots. The chalky white color may become a dingy white after long weathering, but the volva and the roots are always present even on the oldest plants. I have yet to find a single plant *in situ* that did not have these two latter characters. All mature plants found in the field had chalky white endoperidia when fresh, while only those collected before or while emerging and on which the exoperidia had dried had the "tilleul buff" color. One plant out of the 1405 collected was found which had two distinct, perfect mouths. The plants growing in the gypsum flats showed a few minor differences from those growing in sandy areas, the mouths for instance had fewer fibrils (in fact some did not have any, due possibly to loss in weathering), the mouth fissures were longer extending to the base of the spore sac in

many cases, the endoperidia were not so white and the stems shorter, often buried in the sand.

**Tylostoma lysocephalum** sp. nov.

*Sporocarp* globoso usque depresso-globoso, pulverulento-floccoso, 1.5–2.5 cm. alto, 2–3.5 cm. lato, facile ab apice stipitis secedenti. *Exoperidio* pulverulento-floccoso, nec toto secedenti. *Endoperidio* duro, membranaceo. *Stipite* 3–10 cm. alto, 8–12 mm. lato. *Sporis* subglobosis, 4–6  $\mu$  in diam. *Episporio* verrucoso, fulvo.

*Sporophore* originating 3–8 cm. below the surface of soil, consisting of sporocarp, stipe, volva, and bulbous rooting base, with usually only sporocarp appearing above the soil. *Sporocarp* globose to depressed-globose, large, 1.5–2.5 cm. high by 2–3.5 cm. wide, very easily separating from stem apex. *Exoperidium* a sand case, slowly deciduous. *Peridial sheath* a very thick heavy mass of agglutinated hyphae and sand, non-deciduous, 8–12 mm. wide, margin often with an irregular cupulate border, base of sporocarp very heavy so that the head usually comes to rest on the ground with mouth up, when separated from stem, thereby facilitating the dispersal of the spores. *Endoperidium* very tough, thick, membranous, rough with adhering sand and fragments of the exoperidium, warm buff to light buff, slowly weathering to dingy white. *Mouth* raised with a scanty fibrillose peristome, circular to elliptical, often with erumpent lacerate edges in age. *Collar* short, distinct from peridial sheath, 4–5 mm. distant from stem. *Stipe* stout, 3–10 cm. tall by 8–12 mm. thick, usually uniform, but sometimes slightly tapering downward, rough with coarse brown scales, which are slowly deciduous under weathering, usually with adhering sand-clay particles of soil, apex of stipe when disjointed from socket, concave to convex with a light buff smooth surface, also base of stipe often separating from enclosing bulb leaving a smooth slightly swollen end. *Volva* inconspicuous, often filled with soil, enclosed by a ball of hyphae and sand; *base of stipe* bulbous and radicating; *bulb* large 8–15 mm. wide, composed of hyphae and soil; *roots* short, stout and solitary. *Gleba* cinnamon-rufous. *Capillitium* hyaline, thinner than spores, 3–4.5  $\mu$  thick, walls thick, lumen closed except here and there a narrow slit, septa swollen, transverse to slightly oblique. *Spores* subglobose, 4–6  $\mu$ , usual size 5.6  $\mu$ . *Epispor* verrucose, fulvous.

**HABITAT:** Solitary or gregarious in groups of 3–6 individuals, on mesquite-sand dunes, under the mesquite brush in partial shade, or in partial shade of other desert shrubs.

**DISTRIBUTION:** New Mexico. DONA ANA COUNTY, 6 miles



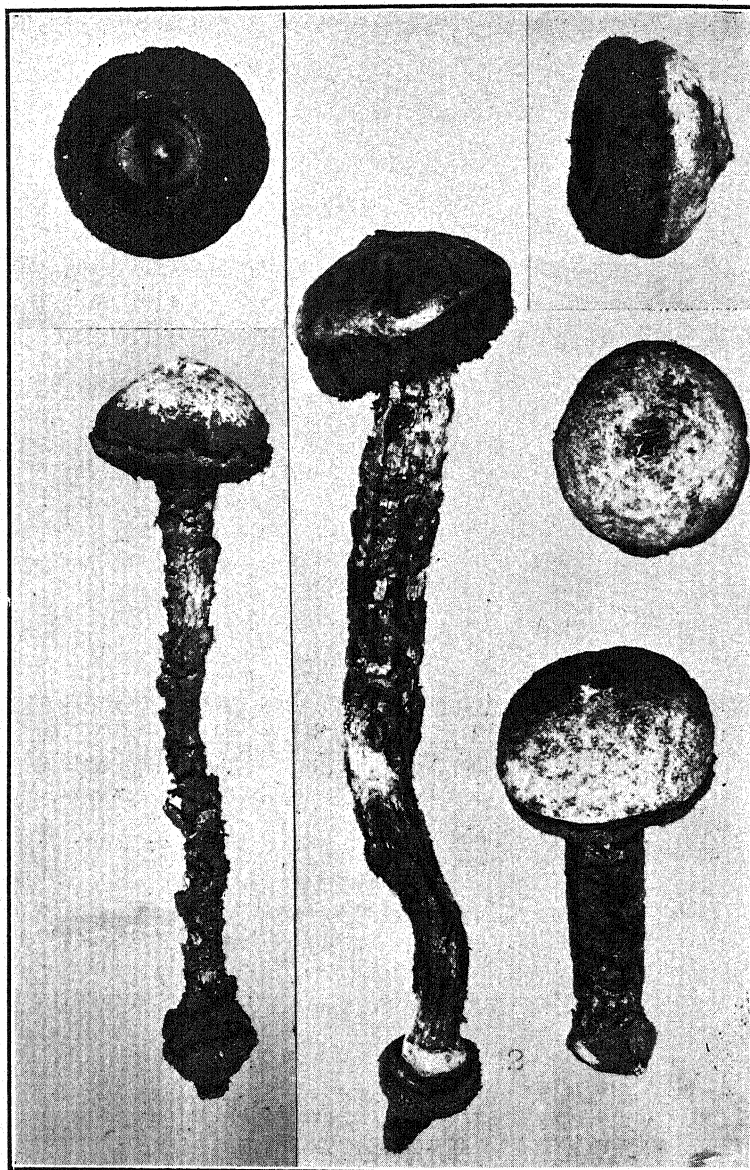


FIG. 2. *Tylostoma lysocephalum*,  $\times 1$ .

from Mesilla Park in Tortugas Mts., elevation, 4600 feet, *Ivan H. Crowell*, April 1, 1937—1 plant 8158 (Crowell no. 2458); Jornada Experimental Range, elevation 4150 feet, *W. H. Long, Ivan H. Crowell and Victor O. Sandberg*, May 2, 1937—9 plants 8178; east of San Augustine Pass on Highway 70, elevation 5500 feet, *W. H. Long and David J. Stouffer*, September 7, 1941—1 plant 9583. LINCOLN COUNTY, 8 miles south of Oscuro, elevation 5000 feet, *W. H. Long and David J. Stouffer*, April 18, 1941—1 plant 10081, *David J. Stouffer*, April 18, 1942—47 plants 10086; Pinos Mts. north of Cedarvale, elevation 7000 feet, *David J. Stouffer*, July 12, 1941—6 plants 9393; 20 miles N.W. of Corona, elevation 6500 feet, *David J. Stouffer*, July 23, 1941—1 plant 9551. LUNA COUNTY, 10 miles west of Deming on Highway 70, elevation 4300 feet, *W. H. Long and David J. Stouffer*, September 9, 1941—50 plants 9615, September 12, 1941—113 plants 9639 (Type), September 13, 1941—50 plants 9658; *W. H. Long*, April 24, 1942—16 plants 10064.

This species is unique in the looseness with which its sporocarps are attached to the stipes, more of these being found loose on the ground than on the stipes. These sporocarps (heads) are also very heavy due to the large amount of soil that clings to the peridial sheath, especially on those sites where there is a large amount of clay in the soil. It is also an unusually large, coarse plant, unsightly from the dirt clinging to heads, stipes and stipe bases.

***Tylostoma opacum* sp. nov.**

*Sporocarpo* depresso-globoso 10–15 mm. alto, 12–20 lato. *Exoperidio* pulverulento floccoso, nec toto secedenti. *Ore* parum fibrilloso. *Stipite* 2–5 cm. alto, 4–6 crasso. *Sporis* subglobosis opacibus, 7–11  $\mu$ . *Episporio* crasso, reticulato, prominenti, verrucoso.

*Sporocarp* depressed-globose, 10–15 mm. high by 12–20 mm. broad. *Exoperidium* a thin floccose layer of hyphae and sand, Sayal brown to fawn color, wearing away very slowly, leaving traces of flocci as inherent patches on the endoperidium. *Peridial sheath* remaining permanently as a thin layer of hyphae and sand. *Endoperidium* membranous, white, leathery in texture, smooth, thin, rather tough, attached firmly to stem apex. *Mouth* slightly raised, surrounded by a scanty fibrillose zone, concolorous with the exoperidium, narrowly elliptical, often enlarging in age. *Stipe* 2–5 cm. high by 4–6 mm. thick at apex, even or tapering somewhat

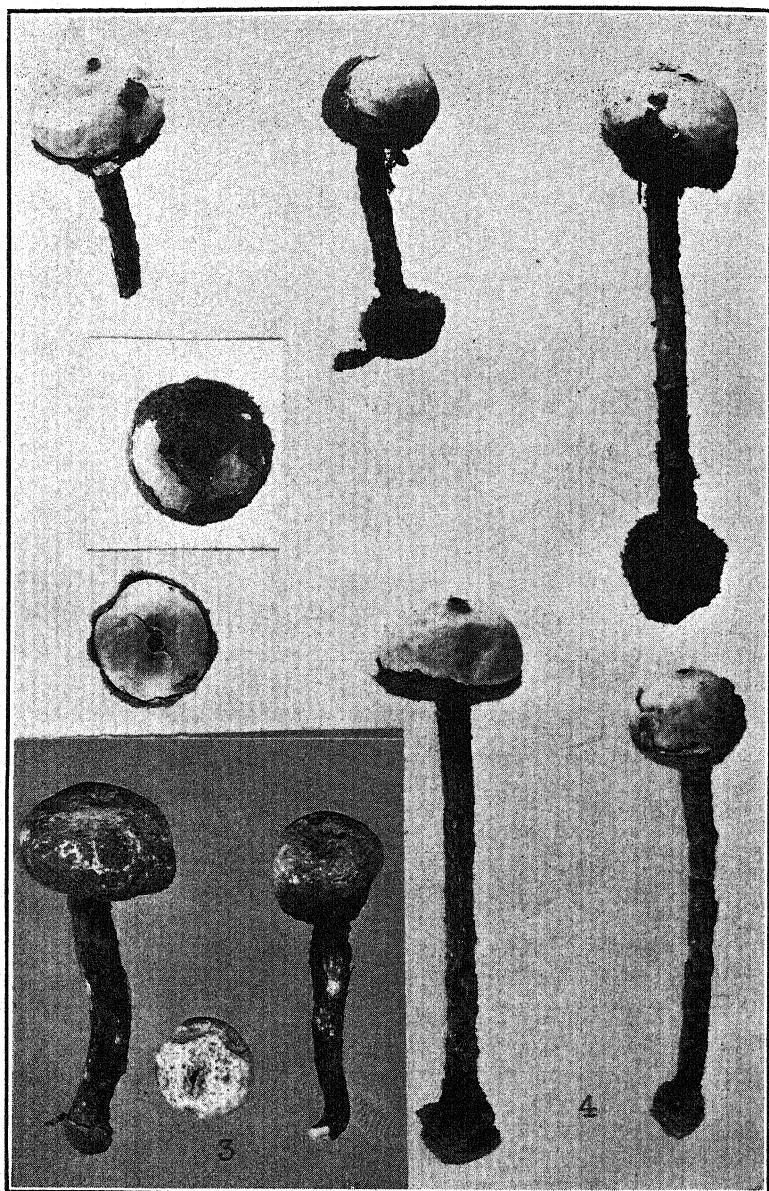


FIG. 3. *Tylostoma opacum*,  $\times 1$ ; 4, *Tylostoma involucrellum*,  $\times 1$ .

toward base, cortex "Sudan brown," splitting into longitudinal fibres which tardily peel off leaving a white surface, white inside, woody, slightly bulbous at base; *bulb* hard, woody. *Gleba* brown-ochre to ferruginous; *capillitium* hyaline, sparingly branched, occasionally anastomosing, threads 4–11.5  $\mu$  thick in lactic acid, 8.8–12.7  $\mu$  thick in benzoazuren mount, usual size 4–5  $\mu$ , some parts of unequal thickness in same thread, walls thick, unpitted, lumen in lactic acid very slight, represented only by a slit here and there, threads rounded and slightly swollen at the septa. *Spores* subglobose, opaque in water mount, 7–11.2  $\mu$  in diameter, usual size 8.4  $\mu$  including verrucae; *epispore* chestnut brown, walls up to 2.5  $\mu$  thick; reticulate with a distinct halo, covered with coarse, hyaline, finger-like processes which are up to 1.7  $\mu$  tall by 2.5  $\mu$  thick at base in lactic acid, 4.4  $\mu$  tall in benzoazuren, often deciduous, especially in a lactic acid mount under pressure on the cover glass, leaving the main spore center naked, smooth, subglobose to oval, 4.2–5.2  $\mu$  in diameter.

HABITAT: Solitary in heavy adobe soil in open, unshaded areas.

DISTRIBUTION: ARIZONA. PIMA COUNTY, 8 miles from Tucson on road to Sabino Canyon, elevation 2400 feet, *W. H. Long*, September 28, 1939—1 plant 8390. NEW MEXICO. DONA ANA COUNTY, Jornada Experimental Range, about 28 miles west of Las Cruces, elevation 4150 feet, *W. H. Long*, November 12, 1938—6 plants 8286 (Type).

This species is characterized by the very large opaque spores, the strong halo, the reticulate warty surface of the epispore, and the deciduous warts. The type collection was found about 1 mile from the mesquite-sandhill revegetative plat on the Jornada Experimental Range near the road to this area. The Arizona plant was found in an open area in mesquite-catclaw flats (*Prosopis-Acacia*) in a sand-adobe-gravel soil with limestone subsoil. This species seems to be scarce as indicated by the few specimens found. During 1939 and 1941, the original areas were revisited and a careful search was made, but no additional specimens were found.

Only one other species of *Tylostoma*, *T. macrosporum* Cunningham, is known to me with such large spores. However, this species has a tubular mouth, while *T. opacum* has a fibrillose peristome.

**Tylostoma involuocratum** sp. nov.

*Sporocarp* globoso usque depresso-globoso, 5 cm. lato, 6-17 alto, albicanti. *Exoperidio* membranaceo, toto secedenti. *Endoperidio* toto levi, membranaceo. *Ore* mammoso, brevi. *Stipite* 4-9 cm. alto, 5-8 mm. crasso. *Sporis* subglobosis, 4.2-5  $\mu$ . *Episporio*, levi usque granuloso.

*Sporophore* originating 2-6 cm. below the surface of the soil, consisting of sporocarp, stem, and bulbous base. *Sporocarp* globose to depressed-globose, 1-2.5 cm. across by 6-12 mm. high, easily separating from stem. *Exoperidium* strongly and permanently membranous, outer surface a light buff to cartridge buff under sand layer, inner surface white, drying into a thin, very fragile involucre, slowly deciduous in flakes, leaving lacerate shreds of dried membrane on spore sac, often as a thin involucre around the top of the peridial sheath, thus producing a frilled appearance; *peridial sheath* a thick, tough band of agglutinated hyphae and sand, 5 to 7 mm. broad, often with a somewhat cup-shaped flaring upper margin. *Endoperidium* perfectly smooth, very tough, membranous, pale pinkish buff fading to pinkish white with age. *Mouth* tubular, short, often enlarged at base, giving the mouth a mammilate shape, small to medium size, usually circular. *Collar* thick, 3-6 mm. distant from stem. *Stipe* tall, 4-9 cm. high by 5-8 mm. thick, equal or slightly tapering downward, clay color to cinnamon buff, walls thick, woody, often nodose with short brownish scales which point upward, sometimes striate beneath the scales, usually dirty with adhering soil, expanding abruptly into a white, hard, woody disc enclosed by a bulb of hyphae and soil; *volva* none; *radicating base* none. *Gleba* in young stage just before elongating orange-yellow, when fully mature mikado brown; *capillitium* in water mount sub-hyaline, walls thick, no lumen in some threads, sparingly branched, 3-5.6  $\mu$  thick, septa rare not swollen. *Spores* subglobose to broadly oval, 4.2-5  $\mu$  in diameter; *epispore* chestnut color, walls apparently smooth to slightly granulose.

**HABITAT:** Gregarious in small groups of 2-4 individuals, in partial shade under desert shrubs and trees in sandy-clay soil.

**DISTRIBUTION:** ARIZONA, PIMA COUNTY, 8 miles from Tucson on road to Sabino Canyon, elevation 2400 feet, *W. H. Long and Victor O. Sandberg*, February 20, 1934—11 plants 7680, 1 plant 7610 and 1 plant 10014; *W. H. Long and David J. Stouffer*, September 10, 1941—4 plants 9624.

NEW MEXICO, BERNALILLO COUNTY, near Albuquerque, elevation 4950 feet, *W. H. Long*, August 30, 1941—5 plants 9482,

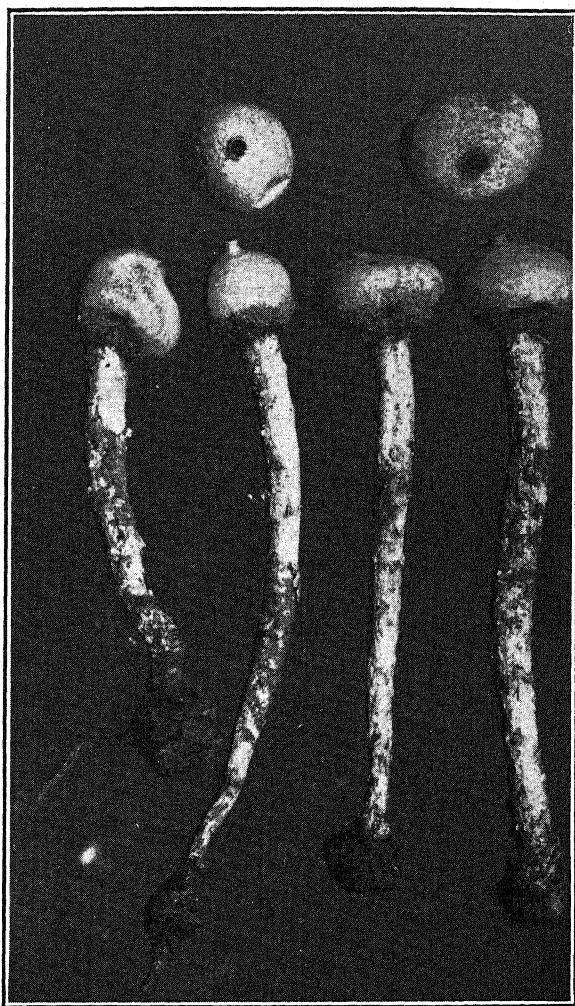


FIG. 5. *Tylostoma excentricum*, fresh plants, just emerged,  $\times 1$ .

November 27, 1941—17 plants 9910, January 19, 1942—18 plants 9976, January 27, 1942—10 plants 9981, April 4, 1942—2 plants 10050; 10 miles south of Albuquerque, elevation 4900 feet, *W. H. Long*, August 29, 1941—14 plants 9480, September 2, 1941—21 plants 9490. VALENCIA COUNTY, 4 miles south of Belen on State road 6, elevation 4800 feet, *W. H. Long*, September 18, 1941—3 plants 9684. DONA ANA COUNTY, Jornada Experimental Range,



elevation 4150 feet, *W. H. Long and David J. Stouffer*, September 7, 1941—1 plant 9587, September 8, 1941—7 plants 9606. LUNA COUNTY, 10 miles west of Deming on Highway 80, elevation 4300 feet, *W. H. Long and David J. Stouffer*, September 9, 1941—21 plants 9482, 5 plants 9616 and 9 plants 9617, September 11, 1941—31 plants 9644, September 13, 1941—42 plants 9650 (Type), and 4 plants 9819. LINCOLN COUNTY, 8 miles south of Oscuro, elevation 5000 feet, *David J. Stouffer*, February 17, 1942—25 plants 10018. Near Gallinas Forest Service Ranger Station, elevation 6800 feet, *W. H. Long*, September 6, 1941—1 plant 9676. OTERO COUNTY, White Sands National Monument in gypsum flats, elevation 4250, *W. H. Long and David J. Stouffer*, September 13, 1941—2 plants 9849.

The outstanding characters of this species are the permanently membranous exoperidium, which does not become granular on drying and the pale pinkish white endoperidium surrounded by the lacerate fragments of the membranous exoperidium which gives the sporocarp a frilled appearance. This frilling is a very marked feature and one not observed in other species of *Tylostoma* having tubular mouths, and is especially noticeable in the field when the plants are *in situ* and before they have lost this frilled look from handling by the breaking off of the thin fragile lacerate pieces of the exoperidium. Near Albuquerque this species is found on the mesa east of Kirtland Field Army Airport on *Yucca glauca* mounds, while in the arroyos it is found under *Fallugia paradoxa* bushes. In the Oscuro and Denning areas the plants grow on top of the mesquite-sand dunes in the shade of the mesquite trees (*Prosopis juliflora*).

***Tylostoma excentricum* sp. nov.**

*Sporocarpio* globoso, 6–15 mm. alto, 10–18 mm. lato, *exoperidio* pulverulento, ex parte secedenti. *Ore* regulari integro prominulo excentrico. *Endoperidio* flavido-avellaneo, aetate albicanti. *Stipite* attenuato, 3–9 cm. alto, apice 3–6 mm., basi 2–4 mm. crasso. *Sporis* globoso-ovatis, 4.5–5.6  $\mu$ . *Episporio* *levi*.

*Sporophore* originating 3–5 cm. below the surface of the soil, consisting of sporocarp, stipe, volva and bulbous radicating base. *Sporocarp* globose to slightly depressed-globose, 6–15 mm. tall by 10–18 mm. wide, not easily separating from apex of stem, sometimes one-sided or excentrically shaped. *Exoperidium* a thin sand

case, early deciduous; *peridial sheath* non-deciduous, consisting of hyphae and sand, tough, 3–6 mm. wide by 2–3 mm. thick, occasionally partially peeling off. *Endoperidium* tough, membranous, pale drab gray when fresh, fading to pale olive buff then to dingy white in age, smooth. *Mouth* tubular, tubes long, prominent, usually excentrically placed on the sporocarp, 1–2 mm. tall by 1–2 mm. wide, circular flaring at top. *Stipe* slender, fragile, very weak at top of bulb and often breaking off there, usually tapering downward, 3–9 cm. tall, 3–6 mm. thick at top by 2–4 mm. thick at bulbous base, white with thin fugaceous scales. *Volva* very inconspicuous, usually clasping the stem; *bulb* small, 5–8 mm. in diameter, surrounding the volva; *root* small, fibrous, single or often absent. *Gleba* cinnamon to raw sienna. *Capillitium* sub-hyaline, walls thick, threads thicker or same size as spores. *Spores* globose to oval, 1-guttulate, guttule large, some spores apiculate,  $4.5\text{--}5.6\ \mu$ ; *epispore* appearing smooth, color smoky.

**HABITAT:** Solitary on low sand dunes in open unshaded spots, often thickly scattered over restricted areas.

**DISTRIBUTION:** BERNALILLO COUNTY, 3.5 miles from Albuquerque on Highway 85 on south end of Sandia Plaza Addition, elevation 4950 feet, *W. H. Long*, May 30, 1941—140 plants 9395 (Type), June 5, 1941—10 plants 9347, February 8, 1943—1 plant 10405, February 12, 1943—1 plant 10420, June 20, 1943—4 plants 10368, 2 plants 10369; east of Sandia Vista Court on Highway 85, elevation 4950 feet; *W. H. Long*, June 20, 1940—1 plant 10418, June 20, 1941—83 plants 9360, August 23, 1941—15 plants 9468, October 16, 1941—22 plants 9822, February 1, 1942—10 plants 9997, May 24, 1942—20 plants 10254, January 22, 1943—21 plants 10421, February 15, 1943—2 plants 10440, July 1, 1943—10 plants 10371, August 7, 1943—10 plants 10386.

SANDOVAL COUNTY, 2 miles south of Bernalillo, west of Highway 85, elevation 4950 feet, *W. H. Long*, August 24, 1941—5 plants 9471.

***Tylostoma meristostoma* sp. nov.**

*Sporocarpio* subgloboso usque depresso-globoso, 5–10 mm. alto, 6–18 mm. lato. *Exoperidio* pulverulento-floccoso, nec toto secedenti, albicanti. *Endoperidio* papyraceo. *Ore* irregulare lacerato, indefinito, plano. *Stipite* tenui, 3–6 alto, 2–5 mm. crasso, albicanti. *Sporis* ovatis, subglobosis,  $4\text{--}7\ \mu$ .

*Sporophore* originating 2–4 cm. below the surface of the soil, consisting of sporocarp, stipe, volva, and radicating base. *Sporo-*



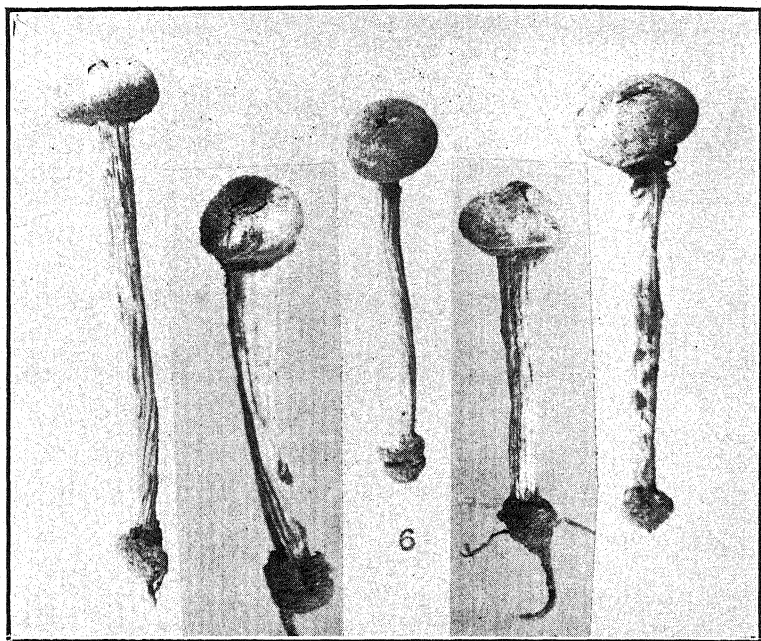


FIG. 6. *Tylostoma meristostoma*,  $\times 1$ .

*carp* subglobose to depressed-globose, 5–10 mm. high by 6–18 mm. in diameter, sometimes concave beneath from pushing through the soil when emerging, firmly attached to stem apex. *Exoperidium* a sand case of flocci and soil, inner layer consisting of dingy white flocci, adhering very tightly to endoperidium, very slowly and imperfectly deciduous; *peridial sheath* a thin permanent band of hyphae and soil 3–5 mm. broad. *Endoperidium* dingy white, thin, papyraceous, fragile around mouth, rough from the adhering flocci of the exoperidium. *Mouth* indefinite, plane, at first a mere slit, soon becoming an irregular lacerate orifice (FIG. 6), whose edges may break off leaving a rounded aperture 3–4 mm. in diameter, naked with no signs of fibrils. *Collar* rather prominent, entire, restricted round top of stem. *Stipe* slender, 3–6 cm. tall by 2–5 mm. thick, even or a few tapering slightly toward base, white, smooth or striate from drying, seated in a small volva; *rooting* with one main root and often one or more side rootlets (FIG. 6). *Gleba* ferruginous; *capillitium* hyaline, threads short like those of a *Disciseda*, thin walled, sparingly branched, 4.2 to 7  $\mu$  thick, ends rounded, no septa seen. *Spores* oval,  $4.2 \times 6 \mu$  to  $5.6 \times 7 \mu$ , or subglobose  $5.6\text{--}6 \mu$ , usually 6  $\mu$  in diam.; *epispore* smooth, thin walled, chestnut color.

HABITAT: solitary in open, unshaded alkaline sand-clay soil.

DISTRIBUTION: NEW MEXICO, BERNALILLO COUNTY, 3.5 miles north of Albuquerque on Sandia Plaza Addition on Highway 85, elevation 5000 feet, *W. H. Long*, November 2, 1941—2 plants 10416, February 12, 1943—1 plant 10419, August 11–12, 1943—12 plants 10392 (Type).

This species belongs in Lloyd's group 7, having a mouth with an indefinite torn aperture and not surrounded by a fibrillose peristome. Lloyd placed 4 species in this group—*Tylostoma Rickii*, *T. australianum*, *T. Readeri* and *T. egranulosum*. *T. Rickii* has a dark reddish brown peridium and a stipe dark reddish brown with a fibrillose, sheath-like cortex, characters which would exclude my plant; while the other 3 species given by Lloyd have been listed by Cunningham as synonyms of *T. australianum*. I have examined the type of *T. australianum* and am sure that *T. meristostoma* is a different plant. *T. australianum* as described by Cunningham apparently does not belong to Lloyd's plant of this name nor to my species.

The type material of *Tylostoma meristostoma* was growing in an alkaline hard pan soil in a live prairie dog town (*Cynomys ludovicianus arizonensis*). Seven of the plants were collected August 11, 1943, three days after a heavy summer rain; all were fresh in various stages of emergence with the sandy exoperidia on sporocarps and stipes still soft, while 2 plants already had slit mouths. Five more plants were found August 12, 1943, some 50 feet from the first location, four having just emerged, while the 5th plant was older and evidently had emerged before the last rain. This plant was dry and had lost the outer sandy coat of the exoperidium, but not the inner flocci. Its mouth was an irregular round hole 4 mm. in diameter.

All the fresh plants were placed, as soon as collected, in wet soil for several days with their bases buried in the soil then put in direct sunlight and wet every 24 hours for several days. The stipes completed their elongation, but the sandy exoperidia remained unchanged and all of the plants developed the slit mouths after several days of drying.

I have collected and examined several thousand *Tylostoma* plants and was dubious that any species had a normally slit mouth as de-

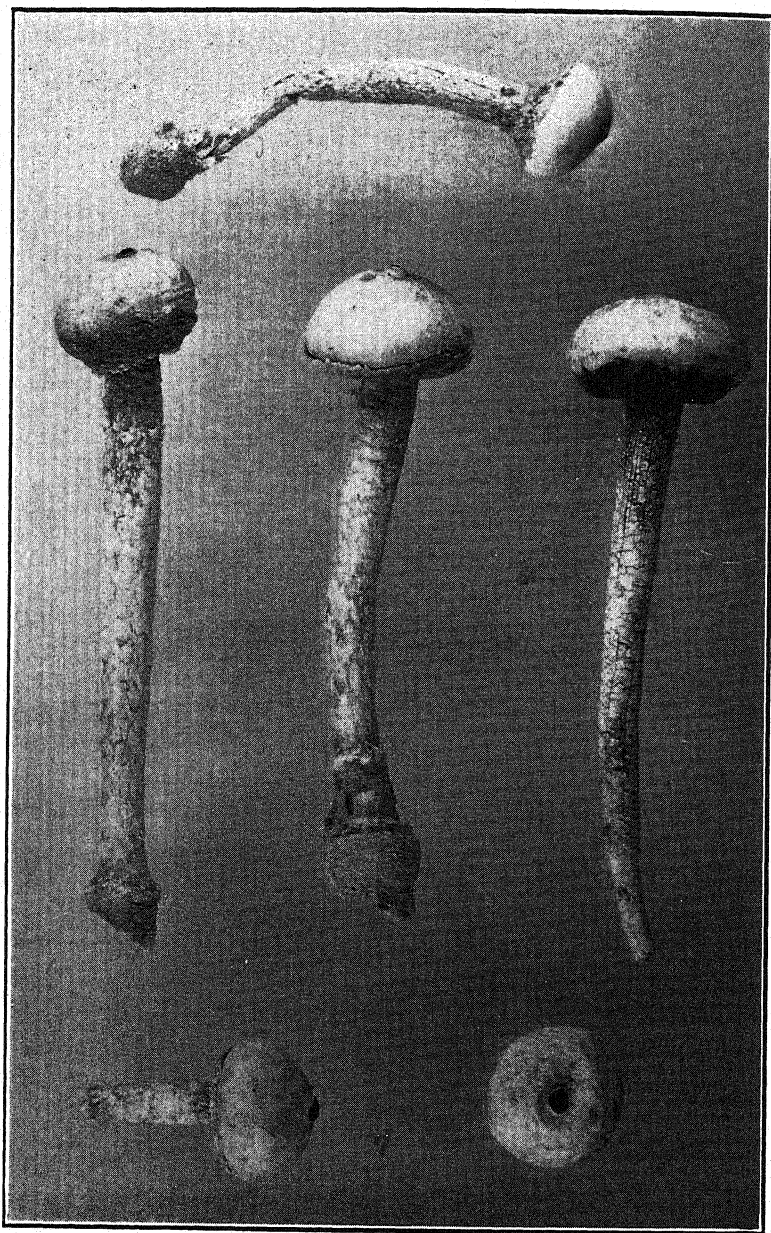


FIG. 7. *Tylostoma macrocephalum*,  $\times 1$ .

scribed by Lloyd for his group 7. I have found any number of plants with irregular, lacerate mouths but a careful study of such plants showed that this mouth condition was due to age and weathering and therefore was not their normal condition when fresh. These lacerate mouths had either been fibrillose or tubular and had become so worn by weathering that these distinguishing mouth characters had disappeared. I was therefore much surprised to find plants with slit, lacerate mouths as a normal condition when fresh.

***Tylostoma macrocephalum* sp. nov.**

*Sporocarpio* subgloboso usque depresso-globoso, 8-15 mm. alto, 12-28 mm. lato, regulari, integro. *Exoperidio* semimembranaceo, toto secedenti. *Endoperidio* levi albicanti, membranaceo. *Ore* mammoso, 2-4 mm. in diam. *Stipite* 5-13 cm. alto, 5-12 mm. lato, lignoso. *Sporis* globosis, 4.2-5.6  $\mu$ . *Episporio* verruculoso.

*Sporophore* originating 4-8 cm. below the surface of the soil, consisting of sporocarp, volva and bulbous radicating base, underside of sporocarp and stipe thinly covered with a clinging arachnoid mycelium containing soil particles which are easily brushed off.

*Sporocarp* subglobose to depressed-globose, 8-15 mm. high by 12-28 mm. in diameter, firmly attached to stipe apex. *Exoperidium* semi-membranous, thin, outer surface grayish white, inner cartridge buff, early and completely deciduous; *peridial sheath* a broad thin band of hyphae and soil, on some plants assuming a cup-like shape, the sides of the cup being the unshed membranous fragments of the exoperidium. *Endoperidium* smooth, dingy white, very tough, membranous. *Mouth* tubular, short, tough, medium to large size, 2-4 mm. in diameter, circular or broadly elliptical. *Stipe* 5-13 cm. tall by 5-12 mm. thick, white, stout, straight, even or slightly tapering toward base, woody, scaly, often becoming transversely rimulose with age after the scales have fallen. *Volva* surrounding the hard woody, globose base of stipe, small, friable, enclosed in a globose mass of hyphae and soil, often having an inner secondary volva of the lacerate fragments of the stipe which were torn loose from under the sporocarp on emerging. *Base of stipe* radicating, roots central, stout, thick and short. *Gleba* cinnamon rufous to ferruginous. *Capillitium* hyaline, 5-5.6  $\mu$  thick, walls thick, lumen none or with very narrow slits here and there, sparingly branched, occasionally anastomosing, some threads unequal in thickness in same thread, no septa seen. *Spores* globose, rarely oval, 4.2-5.6  $\mu$ , usual size 5  $\mu$ , with one very large guttule, or

oil globule, nearly filling the interior of the spore; *epispore* verruculose, walls thick chestnut brown.

HABITAT: solitary or gregarious in small groups in alkaline sand-clay soil, and in open spots in gypsum flats on mounds of dead *Atriplex canescens*.

DISTRIBUTION: NEW MEXICO, LINCOLN COUNTY, near Corona, elevation 7100 feet. *W. H. Long and David J. Stouffer*, April 21, 1940—1 plant 9190; *David J. Stouffer*, June 17, 1941—11 plants 9392; 8 miles south of Oscuro, elevation 500 feet. *David J. Stouffer*, February 20, 1942—13 plants 10022. OTERO COUNTY, White Sands National Monument, elevation 4250 feet, in flats west of first gypsum dune,  $\frac{1}{3}$  mile N.W. of Administration Building, *W. H. Long and David J. Stouffer*, September 13, 1941—3 plants 9648, 2 plants 9757, April 22, 1942—11 plants 10111; in an adjacent gypsum flat, 11 plants 10113 (Type). 20 miles west of Tularosa in white sands area (gypsum), elevation 5000 feet, *W. H. Long and David J. Stouffer*, September 14, 1941—13 plants 9685. SANDOVAL COUNTY, 5 miles west of San Ysidro on state highway 84, elevation 6200 feet, *W. H. Long*, July 9, 1941—11 plants 9386. BERNALILLO COUNTY, south of Kirtland Field airport, Albuquerque, N. M., elevation 5000 feet, *W. H. Long*, September 1, 1941—17 plants 9481, November 28, 1941—1 plant 9913.

The 2 small flats or valleys where the plants were found in the White Sands National Monument were entirely surrounded by gypsum dunes (hydrous calcium sulfate) which have no drainage outlets so that the soil is heavily impregnated with gypsum from rain water and from windblown particles of gypsum settling in the flats.

All specimens listed are deposited in the Long Herbarium at Albuquerque, New Mexico, unless otherwise stated.

#### ACKNOWLEDGMENTS

I am under many obligations to Mr. John A. Stevenson for loan of material and for important advice; to Dr. Fred J. Seaver for loan of material; to Mrs. Vera Miller for checking the glebal characters of *T. opacum*; to Dr. David H. Linder for advice on the

names; to Prof. Sultan Ahmad for valuable material from India; to the University of North Carolina for loan of material; to the National Parks Service for permission to investigate the fungus flora of the White Sands National Monument.

ALBUQUERQUE,  
NEW MEXICO.

## THE HORSE-HAIR FUNGI

FRED J. SEAVER

(WITH 1 FIGURE)

A peculiar fungus has recently come to the writer for determination and it was concluded that it belonged to the above named group. So far as known the horse-hair fungus or blight represents the mycelial stage of a *Marasmius*, based on material collected in Australia and described by Kalchbrenner as *Marasmius crinis-equi* (Grevillea 8: 153. 1879). Later Berkeley (Jour. Linn. Soc. 18: 383. 1883) changed the spelling of the specific name to "*equicrinis*." The original spelling, however, should be retained. There are several closely related species belonging to this category. The following description of the typical species is given by T. Petch (Ann. Royal Bot. Gard. Peradeniya 6: 43-44. 1915):

"The mycelium of this species is the common horse-hair blight of Ceylon. It consists of a smooth, tough, black cord, from one-tenth to one-eighth of a millimetre in diameter, which runs in all directions over bushes and trees, up to a height of 20 feet above the ground, attached to the living stems and leaves at intervals of one to four centimetres, or throwing out long free threads to adjacent branches. Its course is quite a random one. After proceeding along a branch for a short distance, it may leave it and attach itself to a leaf, and after crossing several leaves may return to its original branch. Or it may travel from a branch to a leaf via the leaf stalk, and may make a complete circuit of one surface of the leaf before proceeding further. In general, the whole of the mycelium is aerial; it is not connected with any mycelium on the ground, and does not ascend the tree from the ground level. It has been observed at the base of *Hevea* trees, where it grows on the outer dead bark, but this is an exceptional case, and it has not been known to climb up to the leaves from that position.

"When the leaves die they adhere to the mycelium until they

decay and disintegrate, and consequently there is produced a tangled mass of leaves and mycelium, with sometimes twigs also, suspended in the bush or tree. The mycelium, however, does not appear to be parasitic."

The American material sent for determination consists of the mycelial stage only, but agrees quite closely with the above description. The material was encountered by our soldiers during maneuvers near Evans, Louisiana. According to reports the strands which extended from branch to branch often contacted the



FIG. 1. A wisp of horse-hair fungus collected by Lt. W. P. Comstock, Jr. in Louisiana, and sent in for determination.

boys' faces as they plunged through the thickets and were thought to be spider webs. Finally the material photographed was sent in for determination. On request for further information the following note was enclosed:

"There was a considerable amount of horse-hair blight in scrub oak at about eye level in bivouac area S.W. Evans [Louisiana], Dec. 5, 1943. Found by 1st Lt. W. P. Comstock, Jr., used for sewing on buttons." The use made of these black mycelial strands by the soldiers is exceedingly interesting. Whether they are tough enough to make a satisfactory substitute for thread we are unable to say.

So far as the writer can learn only one previous collection has been reported in continental North America. This specimen is in



the Farlow Herbarium at Harvard University and was obtained by Brother Arsene, an amateur collector, and was found at Lafayette, Louisiana. So little is known of the fungus in America that it seems worth noting at this time.

THE NEW YORK BOTANICAL GARDEN.

# A NEW SPECIES OF METARRHIZIUM ACTIVE IN DECOMPOSING CELLULOSE

SETH POPE

(WITH 2 FIGURES)

## INTRODUCTION

A fungus, isolated from deteriorated baled cotton stored in Washington, D. C., and tentatively assigned by Dr. Charles Thom to the genus *Metarrhizium*, was reported by Greathouse, Klemme, and Barker (4) to have shown extraordinary activity in decomposing cotton fabric in certain pure-culture tests. This fungus has since been used in the Division of Cotton and Other Fiber Crops and Diseases, and in other laboratories, in connection with the evaluation of mildewproofing agents or rot resistance of fabrics (5). It is easily handled in culture, sporulates freely, and has remained stable in its cultural characteristics and cellulose-decomposing activity for the past 3 years. Preliminary studies have indicated that this fungus is not identical with any known species of *Metarrhizium*, so it appears desirable to describe it as new.

## LITERATURE REVIEW

Sorokin (10) in 1879 transferred Metschnikoff's *Entomophthora anisoplia* (6) to the genus *Metarrhizium*, making the new combination *M. Anisopliae* (Metsch.) Sorokin. Rorer (9), Stevenson (12), and Petch (8) give extensive bibliographies of this fungus.

Vuillemin<sup>1</sup> (15) described *Penicillium Anisopliae* as forming a large thallus of which the filaments were compressed and branched, forming small hummocks, often confluent and disappearing under the mass of conidia they produced. Sterigmata and the branches,

<sup>1</sup> Since Sorokin's papers were not available, the description of *M. Anisopliae* was taken from Vuillemin (15).

either isolated, in pairs, or in verticils, arose below the septa of the upper part of this stalk. The conidia were formed in basipetal succession at the expense of the sterigmata, and were united by a disjunctor which was a modification of the membrane, flattened and compressed by the pressure of the growth of new conidia. The resulting columns of conidia composed of conidial chains often reached a length of  $800\ \mu$  or more. The conidia were olive green in color, and cylindrical, with rounded ends. Chlamydo-spores were found in cultures grown on carrots.

The conidial measurements of *M. Anisopliae* when grown on various media have been reported to be  $4.8 \times 1.6\ \mu$  (14). Other workers report measurements ranging from  $4-5 \times 2\ \mu$  to  $7-15 \times 2.5-3.5\ \mu$  (1, 8, 9, 15).

#### CHARACTERISTICS OF THE FUNGUS

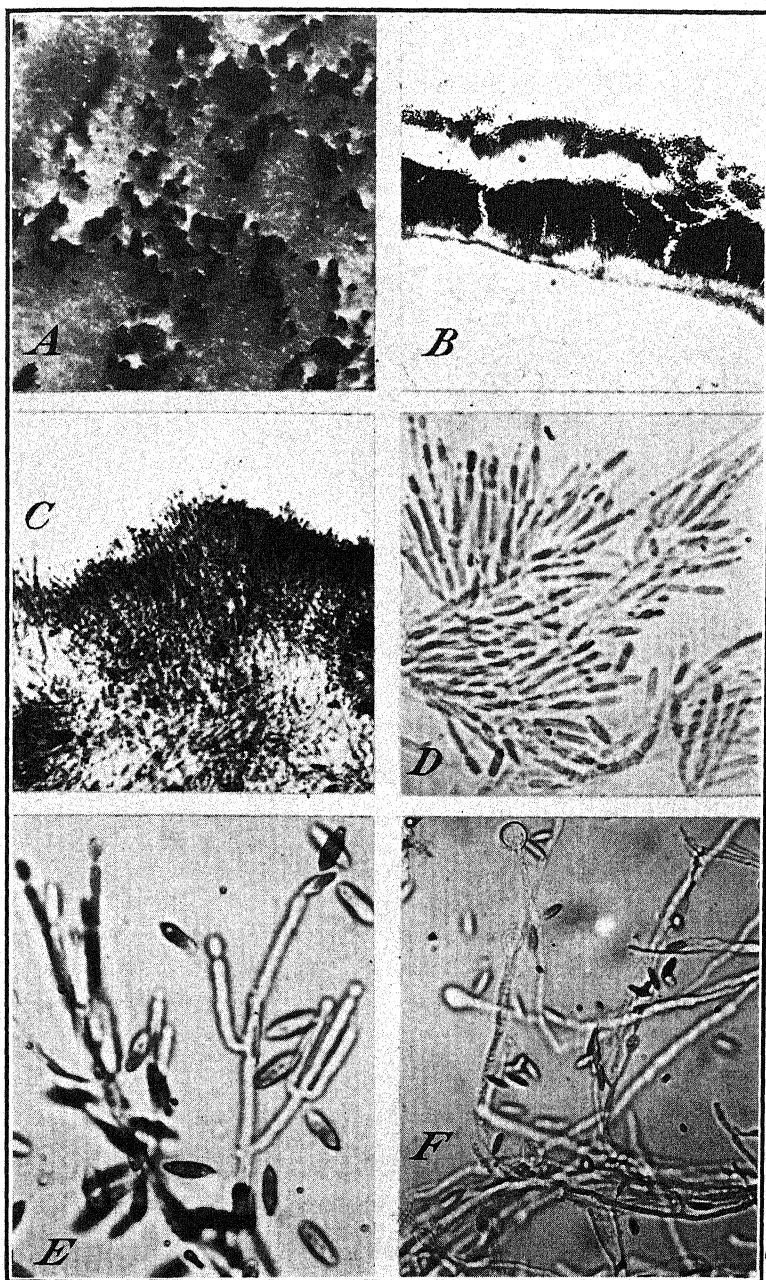
The fungus, growing on filter paper, at first produces a sparse white mycelium in which small tufts of conidiophores arise. These conidiophores are compact, forming a palisade layer in each tuft (FIG. 1, *B* and *C*). The moist conidial masses produced on these tufts often coalesce, forming masses 0.5-2 mm. in diameter (FIG. 1, *A*). The conidia are dusky olive green to olivaceous black,<sup>2</sup> cylindrical, with rounded ends,  $6-9.6$ ,  $1.5-3.9\ \mu$ , formed on sterigmata in basipetal succession and united by disjunctors, but breaking away in the conidial mass soon after formation.

The conidiophores are penicillately branched  $50-85\ \mu$  long, erect, and septate. The ultimate branches are verticillate, composed of 1 to 3 sterigmata each,  $10$  to  $22\ \mu$  long (FIG. 1, *D* and *E*).

Chlamydo-spores are produced in bulbous terminal portions of the hyphae found near the substrate and embedded in the mycelium (FIG. 1, *F*). The mature chlamydo-spore is nearly round, smooth with a small tapered papilla at one side, buckthorn brown, and  $7.4$  to  $9\ \mu$  in diameter.

<sup>2</sup> Ridgeway, R., Color Standards and Nomenclature, 1912, pl. XLI and XLVI.

FIG. 1. *M. glutinosum*. *A*, filter paper culture,  $\times 8.5$ ; *B*, section of filter paper culture,  $\times 100$ ; *C*, palisade arrangement of conidiophores,  $\times 200$ ; *D*, conidiophores,  $\times 530$ ; *E*, conidiophores,  $\times 900$ ; *F*, chlamydo-spore formation,  $\times 530$ .



The above characteristics indicate that the fungus belongs in the genus *Metarrhizium*, and it is described as new.

***Metarrhizium glutinosum* sp. nov.**

Mycelial mat, grown on filter paper (in contact with an inorganic nutrient solution<sup>3</sup>), pure white with dusky olive green to olivaceous black conidial masses on tufts of mycelium; conidiophores up to  $75\ \mu$  long, smooth, erect, septate, penicillately branched above, forming a palisade layer in tufts on which olivaceous black glutinous masses of conidia are produced; conidia catenate, borne directly on fingerlike sterigmata, conidial chains distinguishable in masses only in early stages of formation, conidia elongate-ovoid, smooth, dusky olive green to olivaceous black,  $6-9.6 \times 1.5-3.9\ \mu$ . A type specimen has been placed in the Mycological Collections of the Bureau of Plant Industry, Soils, and Agricultural Engineering under the identification number 1334.2.

Sterigmatibus clavatis  $10-22\ \mu$  longis; conidiis cylindraceis utrimque rotundatis  $6-9.6 \times 1.5-3.9\ \mu$  glabris olivaceonigris, in massa obscure olivaceis usque olivaceonigris, glutinosis; catenis conidiorum solum in statu juniore evidentibus.

In order to eliminate any possible confusion between *M. glutinosum* and *Gliocladium fimbriatum* Gilman and Abbott, a few of the differences are pointed out.

The conidia of *G. fimbriatum* are borne in moist heads which may coalesce, but no palisade or hymenium-like arrangement of the conidiophores is evident. Moreover, these conidia are produced on flask-shaped phialides which are quite different in shape from the sterigmata of *Metarrhizium* (FIG. 2, A).

The branching of the conidiophores and the structure of the sterigmata are quite similar in *M. glutinosum* and *M. Anisopliae* (FIG. 2, C, E, and D). The principal difference between these two species is found in the conidial masses; those of the former are moist, and the latter dry.

Further comparisons are presented in table 1.

<sup>3</sup>  $\text{NH}_4\text{NO}_3$ , 1 gm.;  $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ , 0.7 gm.;  $\text{K}_2\text{HPO}_4$ , 0.69 gm.;  $\text{KH}_2\text{PO}_4$ , 0.69 gm.; and dist.  $\text{H}_2\text{O}$ —1000 cc.

FIG. 2. A, B, *Gliocladium fimbriatum* after Gilman and Abbott; C, E, *M. Anisopliae*, after Speare; F, *M. Anisopliae*, palisade arrangement of conidiophores after Speare; D, *M. glutinosum*; G, *M. glutinosum* palisade arrangement of conidiophores.

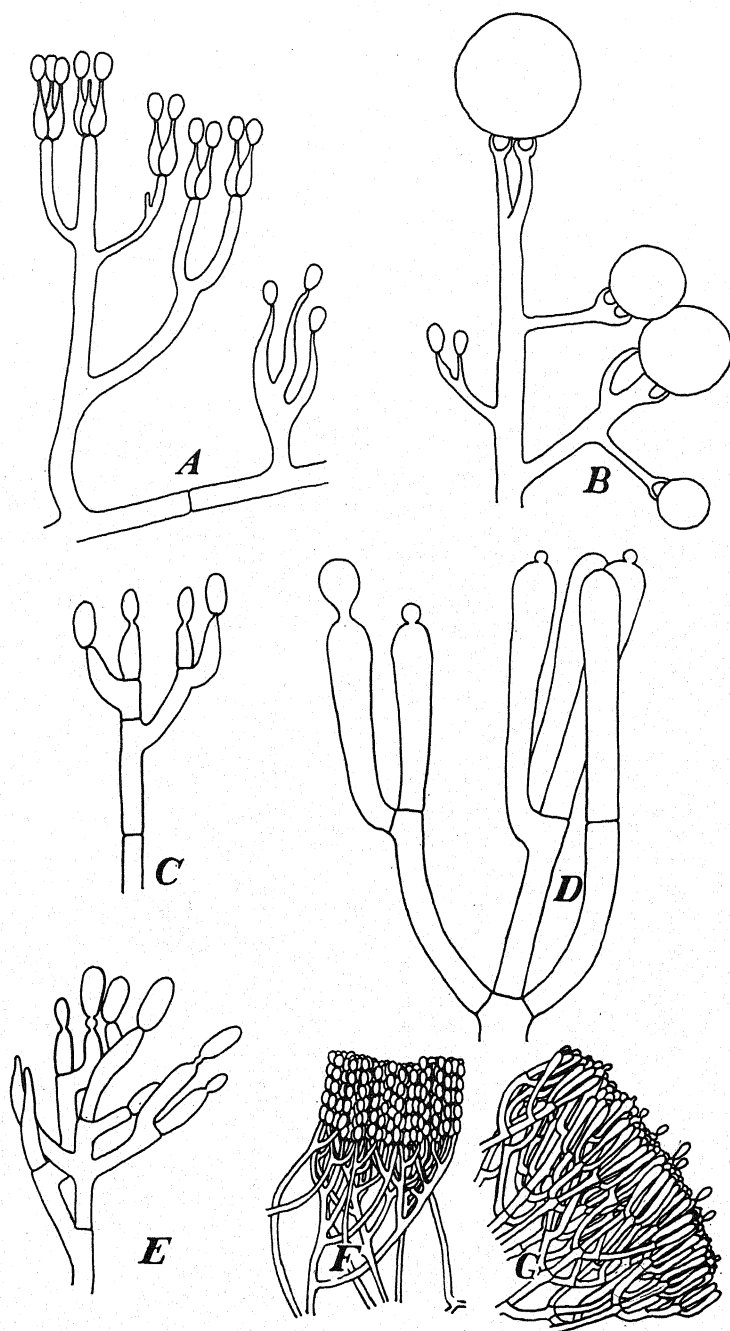


TABLE 1

COMPARATIVE CHARACTERISTICS OF *Gliocladium fimbriatum*, *Metarrhizium glutinosum*, AND *Metarrhizium Anisopliae*

	<i>G. fimbriatum</i>	<i>M. glutinosum</i>	<i>M. Anisopliae</i>
Conidial heads	Round wet balls	Moist masses	Dry columns, conidial chains persisting
Conidia size	6.5-9 $\times$ 2.5-4 $\mu$ (Gilman and Abbott)	6-9.6 $\times$ 1.5-3.9 $\mu$	4.8 $\times$ 1.6 $\mu$ (Thaxter)
Color	Leaf green	Dusky olive green to olivaceous black	Olive green
Conidiophores	Phialides, flask shaped, arising directly from conidiophore or from metulae, forming individual heads	Branched and penicillate, forming palisade layer in tufts	Simple, branched, or penicillate, forming a palisade layer

The branching of the conidiophores, the shape of the sterigmata, and the tendency of the conidiophores to aggregate into palisade arrangements indicate that *M. glutinosum* is more nearly related to *M. Anisopliae* than to *G. fimbriatum* (FIG. 2).

## COMPARISON OF THREE ISOLATES OF METARRHIZIUM GLUTINOSUM

Two other isolates from Maryland soil (2) designated as 1334.1 as 1334.3, were examined morphologically for comparison with isolate 1334.2. Only slight differences in the morphological characteristics have been detected between isolate 1334.1 and isolate 1334.2. However, isolate 1334.3 differs in the cultural characteristics from isolates 1334.1 and 1334.2. The conida and sterigmata are slightly smaller, and the color of the conidia in the early stages of growth is a lighter green than the other two isolates (table 2). Also, colonies of isolate 1334.3, when grown on a nutrient agar or on cotton fabric, tended to produce growth in concentric rings to a greater extent than the other isolates. These isolates appear, however, to be merely strains of *M. glutinosum* and not specifically different.

TABLE 2  
COMPARATIVE CHARACTERISTICS OF THREE ISOLATES OF THE  
GENUS METARRHIZIUM

Isolate	Conidia	Color	Sterigmata size	Conidophore arrangement	Chlamydospores
1334.1	6-9.6 $\times$ 2.9-3.9 $\mu$	Dusky olive green	18-22 $\mu$	Palisade	Brown 7.4-8.1 $\mu$
1334.2	7.5-9.1 $\times$ 2.4-3 $\mu$	Dusky olive green	16-20 $\mu$	Palisade	Brown 7.9-9 $\mu$
1334.3	7.2-8.9 $\times$ 1.5-2.9 $\mu$	Dusky olive green tending to be lighter than Nos. 1 and 2	10-20 $\mu$	Palisade	None observed

## SUMMARY

A new species of *Metarrhizium* which is very active in decomposing cellulose is described as *M. glutinosum*. Comparative observations on two other isolates of the same species are reported.

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BELTSVILLE, MARYLAND

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## BRAZILIAN CHYTRIDS. III. NEPHRO- CHYTRIUM AMAZONENSIS

JOHN S. KARLING

(WITH 28 FIGURES)

In moist soil samples collected by the writer in Brazil several new chytrid species occurred which are particularly significant in relation to the position and formation of opercula in the exit papillae or tubes. These species were isolated in the usual manner by watering the soil samples with animal charcoal water and baiting them with fragments of bleached corn or grass leaves, onion skin, cellophane, and other substrata favorable for the growth and development of chytrids. Within five days to two weeks these substrata became heavily infected with numerous chytrids, and from them subcultures were easily made. In subculturing these fungi, five species were isolated which are very similar to well known North American chytrids but which differ characteristically by sunken opercula in the exit papillae or tubes.

The first of these chytrids, which occurred in limited quantities in cellophane, is so similar in development, structure, and appearance to species of *Diplophlyctis* that until the presence of sunken opercula was observed it was regarded for a long time as a member of this genus. Like species of *Diplophlyctis*, it is characterized by monocentric thalli with apophysate sporangia and resting spores. Furthermore, the tip of the mature exit tube deliquesces as in *Diplophlyctis*, but the processes of zoospore maturation and discharge are delayed until a definite operculum is formed in the exit tube. The presence of an operculum, accordingly, excludes this species from *Diplophlyctis*. The only known intramatrical operculate genus which resembles *Diplophlyctis* in structure is *Nephrochytrium*. Therefore, the present chytrid is assigned temporarily to this genus, although it differs in minor characters from the known species of *Nephrochytrium*. The specific name

*amazonensis* is chosen because the chytrid was collected in the state of Amazonas, Brazil.

***Nephrochytrium amazonensis* sp. nov.**

Sporangiis laevis, hyalinis, pyriformibus,  $12-30 \times 50-140 \mu$ , sphaericis,  $10-60 \mu$ , et obclavatis; tubulo exito,  $5-7 \times 10-130 \mu$ . Operculo  $4-7 \mu$  diam. Zoosporiis sphaericis,  $5-6.5 \mu$ , cum unum globulis sphaericis,  $2-2.5$  diam. Sporiis perdurantibus fusco, ovali,  $20-28 \times 30-40 \mu$ , sphaericis,  $15-35 \mu$ ; membrana verrucosus, spinosus, aut capillatus; germinatione post brevem quietem confecta, contentis spora emergentibus ut sporangium tenuis parietis in superficie fiat.

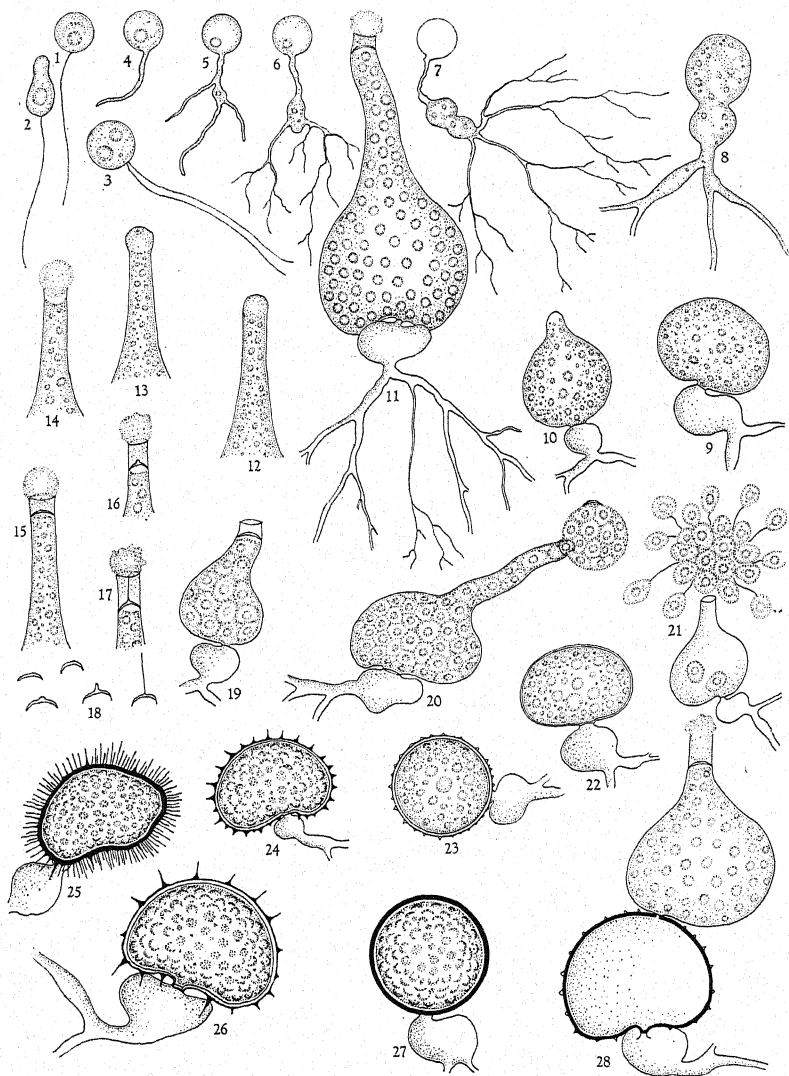
Thallus monocentric, usually intramatrical; consisting of a sporangium or resting spore subtended by an apophysis from which arises an extensive, richly branched rhizoidal system. Sporangia hyaline, smooth, pyriform,  $12-30 \times 50-140 \mu$ , almost spherical,  $10-60 \mu$  in diam., obclavate, flattened and often somewhat kidney-shaped with a short,  $5 \times 10 \mu$ , or an elongate,  $5-7 \times 20-130 \mu$ , tapering exit tube. Tip of tube swelling and softening to form a plug of hyaline material; operculum subsequently developed down in exit tube; operculum shallow saucer-shaped, deeper bowl- or cup- and occasionally somewhat cone-shaped,  $4-7 \mu$  in diam. Zoöspores emerging fully developed and forming a globular mass at the exit orifice before dispersing; spherical,  $5-6.5 \mu$ , with a large refractive globule and a  $35-38 \mu$  long flagellum. Apophysis oval,  $5-12 \times 8-22 \mu$ , flattened, obpyriform, or almost spherical. Rhizoidal system arising from base of apophysis, extending over a radius of  $80-400 \mu$ , main axis up to  $8 \mu$  in diam., richly branched. Resting spores usually oval and somewhat bean-shaped,  $20-28 \times 30-40 \mu$ , almost spherical,  $15-35 \mu$ , and sometimes irregular; content coarsely granular and brown; wall dark brown,  $2-3 \mu$  thick, usually spiny, sometimes verrucose or covered with numerous short setae, rarely smooth; functioning as prosperangia in germination.

Saprophytic in decaying vegetable debris from a small tributary of Rio Candeias, Amazonas, Brazil.

The life history and development of this species are shown in figures 1 to 28. The diagnosis given above, together with the explanations of these figures, is sufficiently complete so that a detailed description of the developmental cycle is unnecessary. Accordingly, the present discussion will be confined to an emphasis on the similarities and differences between *N. amazonensis* and the known species of *Diplophlyctis* and *Nephrochytrium*. In the

former genus, according to the author (2), the incipient sporangium develops first as a swelling at the tip of a branched germ-tube, while the apophysis forms subsequently as a second swelling above the young sporangium. In *Nephrochytrium*, on the other hand, the apophysis is formed first, and the sporangium grows out later as a bud from the large apophysis as has been described by Couch (1), Whiffen (8), and the author (4). This characteristic type of development and the presence of an operculum are regarded as the distinctive characters of *Nephrochytrium*. In *N. amazonensis* an operculum is present, but as far as the writer has been able to determine from observations of a limited number of germinating zoöspores and young thalli, the sporangium and apophysis develop as in *Diplophlyctis*. At least no sharply defined cases of a sporangium budding out from an apophysis have been seen. This phase of development, however, needs more intensive study before definite conclusions can be drawn. Figures 5 and 6 show conspicuous swellings in the branched germ-tubes, while in figures 7 and 8 the apophysis and sporangium are well marked and continuous, although it is not evident that the latter has grown out of the former. The young thallus shown in figure 8 is exceptional in that the connection between apophysis and sporangium is very broad. Usually the isthmus between them is quite narrow (FIG. 9, 10, 18).

Other variations of *N. amazonensis* may be noted at this point. While the sporangia are predominantly pyriform, oval, slightly appressed and bean-shaped, they vary considerably in shape. This is particularly true when they are deeply buried in the substratum. In thick soft pieces of cellophane the sporangia may become greatly elongate, cylindrical, tubular and contorted and vary from 120 to 400  $\mu$  in length by 10–30  $\mu$  in diameter. Under similar conditions they may also become very irregular in shape. In old cellophane cultures in which the pieces of substrata have become surrounded by a slimy substance, the thalli may sometimes develop extramatrically with the sporangium, or resting spore, apophysis, and rhizoidal system completely outside of the substratum. In the development of such thalli, zoöspores germinate with a germ tube and give rise to the sporangia, apophysis and rhizoids in the same manner as is shown in figures 4 to 7. Completely extramatrical



FIGS. 1, 2, spherical and amoeboid zoöspores with a large refringent globule; 3, large abnormal biflagellate zoöspore; 4, 5, germination of zoöspores; 6, 7, development of young sporangium and apophysis; 8, young thallus with apophysis and sporangium continuous; 9, 10, later stages of sporangium development; 11, mature sporangium with operculum and plug of hyaline material in exit tube; 12-15, swelling and deliquescence of tip to exit tube, formation of hyaline plug and operculum; 16, 17, variations of hyaline plug and position of opercula; 18, variations in shapes of opercula; 19, sporangium

thalli are very exceptional, but their occurrence nevertheless indicates how variable chytrids may be in relation to their hosts and substrata.

The distinctive character of this species, however, is the position of the operculum and the changes involved in its development. After the exit tube has been fully formed, the tip begins to swell slightly (FIG. 12, 13), while its bounding wall deliquesces. As a result, a plug of hyaline material forms at the tip and extends for a short distance down into the tube. While these changes are taking place, the more optically heterogeneous protoplasm in the tube contracts downward and its surface usually becomes concave (FIG. 14). Later the border becomes convex and thickens, and eventually an operculum is formed at the surface in much the same manner as the author (5) has described for *Nowakowskiella granulata*. The position of the operculum depends to a large extent on the depth to which the protoplasm retracts in the tube. The opercula are usually shallow saucer- or bowl-shaped (FIG. 18), but occasionally they are pointed, cone-shaped, and surmounted by a peg or tenuous hair.

The plug of hyaline material usually deliquesces and disappears before discharge of the zoospore occurs (FIG. 19). When the zoöspores emerge, the operculum is pushed out so quickly that its presence may be overlooked unless the initial stages are observed. Occasionally it may be found adherent to the enlarging mass of zoöspores on the outside (FIG. 20).

As in *Diplophlyctis*, the resting spores appear to be formed in the same manner as the sporangia, and so far no evidence of the fusion of thalli like that reported by Sparrow (7) has been observed. The young spores may be easily recognized by their thicker walls (FIG. 22) and more refractive content. As they

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shortly before discharge of zoöspores; 20, zoöspores emerging and forming a globular mass at exit orifice; operculum at surface of zoöspore mass; 21, dispersal of zoöspore mass; 22, incipient resting spore; 23, later developmental stage showing rudiments of spines on wall; 24, mature spore with numerous abruptly tapering spines and coarsely granular content; 25, irregular mature spore covered with numerous short setae, among which are interspersed a few spines; 26, mature spore with a few long spines; 27, exceptional smooth, spherical resting spores; 28, germination of resting spore.

mature, the wall begins to turn brown, and incipient warts or spines appear on the surface (FIG. 23). The refractive globules become more highly dispersed so that the content of the spores takes on a coarsely granular appearance (FIG. 25-27). The mature spores may be warty, echinulate, spiny and sometimes covered by short fine hairs. In three cases observed, the walls were smooth (FIG. 27). The spines may be numerous or sparse, very short or fairly long, as is shown in figures 24, 26, and 28. After two to four months under laboratory conditions in New York, the resting spores germinate and form hyaline evanescent sporangia on their surfaces (FIG. 28). In such sporangia the tip of the exit tube deliquesces and forms a plug of hyaline material, while the operculum develops down in the tube in the same manner described above for the primary sporangia. With the exception of the formation of an operculum, the resting spores thus germinate like those of *Diplophlyctis intestina* (Karling (3)) as far as is now known.

While it is not conclusively certain whether or not the sporangium of *N. amazonensis* develops from the apophysis as in other members of the genus, this species is nevertheless included in *Nephrochytrium* for the time being. Further studies on its development as well as the discovery of other similar species may possibly show that the formation of the sporangium from an apophysis is not so distinctive and diagnostic of the genus as the presence of an operculum. *Nephrochytrium amazonensis*, at any rate, is a significant chytrid because of its striking similarity of structure to species of *Diplophlyctis*. This similarity together with the deliquescence of the tip of the exit tube prior to operculum formation suggests that the present fungus may possibly be a transition form between the two genera. While there is no indisputable evidence at hand of such a transition, it is none the less stimulating to postulate that the operculum of *Nephrochytrium* may have evolved through changes of nature shown in figures 12 to 15 from an inoperculate *Diplophlyctis*-like ancestor.

The discovery that an operculum develops although the tip of the exit tube deliquesces and forms a plug of hyaline material emphasizes the need for more intensive study of species with exit tubes or papillae of this type and appearance. *Rhizidium lignicola*

Lindau (6), for instance, is a saprophytic apophysate species with exit tubes very similar in appearance to those of *N. amazonensis*, and it is not improbable that further studies may show the presence of sunken opercula in this species. This may perhaps prove to be true of Zopf's (9) *Amoebochytrium rhizidioides* also.

#### SUMMARY

*Nephrochytrium amazonensis* occurs as a saprophyte in decaying vegetable debris in moist soil samples collected from the Rio Candeias in Amazonas, Brazil. It is strikingly similar in structure to species of *Diplophlyctis*, but forms an operculum in the exit tube after the tip has deliquesced and become filled with a plug of hyaline material. Because of the presence of an operculum it is included in the genus *Nephrochytrium*.

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## NEW GENERA OF FUNGI <sup>1</sup>

ROLF SINGER <sup>2</sup>

When the flora of the flowering plants of the tropics is compared with the temperate flora, it will be obvious that many temperate elements are not represented in the tropics while, vice versa, the tropics are rich in forms unknown in the North. This refers to species as well as to genera, and even families. In mycology, however, these facts do not express themselves in taxonomic terms because most tropical species were forced into one or another of the artificial Friesian genera. When a turn toward smaller natural genera had begun, the data on tropical species were comparatively scarcer than on temperate forms, and, at the same time, the tropics were yielding many interesting novelties while the still numerous new species from temperate countries more or less remained within the framework of the classification established for them during the last years.

It is not surprising, therefore, that the mycologist, when trying to work out the flora of some tropical regions, still discovers many forms which belong in genera hitherto unknown to Science. This was shown, in the Old World's tropics, by Roger Heim's studies on the fungi of Madagascar, and it became still more manifest to the writer when he visited South Florida with its neo-tropical vegetation. The theory of the prevalence of cosmopolitanism in fungi, in the writer's opinion, ought to be abandoned altogether.

### 1. *Boletochaete* Sing. gen. nov.

Boletacearum genus, sporis sub microscopio brunneolo-hyalinis vel melleo-brunneolis, levibus, fusoido-ellipsoideis vel ovoideo-ellipsoideis; basidiis haud voluminosis; cystidiis numerosis; setis hymenialibus coloratis numerosis;

<sup>1</sup> Contribution from the Farlow Herbarium and Laboratories of Cryptogamic Botany no. 209.

<sup>2</sup> The writer wishes to thank Dr. Fred J. Seaver, Head Curator, The New York Botanical Garden, for a loan of the type collection of *Leucomyces mexicanus* Murr., and also Dr. David H. Linder, Curator, Farlow Herbarium, Harvard University, for various tropical materials from special collections.

tramate hymenophori subregulari (haud distincte bilaterali) in adultis; hyphis haud fibuligeris; hymenophoro tubuloso, ad stipitem adnexo; stipite cylindraceo vel ventricosus.

The type species is *Boletus spinifer* Pat. & Baker, Jour. Straits Branch R. A. Soc. No. 78, p. 69. 1918. We have studied the type preserved at Farlow Herbarium. Other species belonging in this new genus are: *Xerocomus* sp. Heim, Bol. Soc. Brot. 13: 53. 1938, and a new species which shall be described here.

The new combination ***Boletochaete spinifera*** (Pat. & Baker) Sing. is proposed.

***Boletochaete brunneosetosa* Sing. sp. nov.**

Pileo sordide cerasino, levi, subvelutino, convexo, 20–32 mm. lato; cuticula ex hyphis catenulatis  $20\text{--}32 \times 12\text{--}14 \mu$ , erectis et irregulariter palisatis, nonnullis autem jacentibus, haud densis, membrana  $1\text{--}1.5 \mu$  crassa in nonnullis, tenuiore autem in aliis, institutis, apice rotundatis, intus pigmento dissoluto brunneo impletis, pigmento intercellulari nullo ornatis consistente.—Tubulis porisque olivaceo-luteis, usque ad 8 mm. longis, subtus convexis, adnexis depressisque circum stipitis apicem, poris majusculis (15 pro 1 cm.); sporis brunneolo-melleis, levibus, oblongo-ellipsoideis, subfusiformibus, depressione suprahilari saepe distincta,  $12\text{--}13 \times 4.5\text{--}5.5 \mu$ ; basidiis  $22\text{--}32 \times 8\text{--}9.5 \mu$ ; cystidiis versiformibus (fusoideo-ventricosus vel clavatis vel fusoideo-acutis), hyalinis, tenui-tunicatis, numerosis,  $33\text{--}66 \times 6\text{--}14 \mu$ ; setis hymenialibus membrana brunnea, levi, crassa ( $1.5\text{--}3.5 \mu$ ), saepe subhyalina in parte basali ibidemque tenuiore, vel unicolori aequalique instructis, acutissimis, fusoideis, rarissime spina laterali gaudentibus, numerosis,  $55\text{--}95 \times 9\text{--}12.5 \mu$ ; tramate hymenophori subregulari (haud distincte bilaterali) in adultis, mediostrato haud densiore neque obscuriore atque vix distincto, strato laterali concolori (pallidissime melleo-hyalino), in tertia externa leniter divergente; hyphis constanter defibulatis.—Stipite concolori cum pileo, ad basin albo, subvelutino, levi, glabro, nudo, aequali, ad ipsam basin autem attenuato, solido, rigido,  $17\text{--}40 \times 2\text{--}5$  mm.—Carne alba, solida; hyphis haud fibuligeris; odore saporeque notabilibus nullis.—Habitatio: Ad humum in silva. Aprili mense. Nengbe, Liberia, Africa Occidentalis. Legit G. W. Harley.

This species differs from *B. spinifera* in having elongate, more deeper colored spores, slender, cylindric stipe, and red pileus and stipe. Another African species, *Xerocomus* sp. Heim, described from Madagascar, which seems to come much closer to *B. brunneosetosa* than *B. spinifera*, still differs in color of the pileus and the stipe and also of the tips of the setae which are said to be olivaceous-yellow. Heim is right comparing his species with *Xerocomus*. As long as there was no proper new genus described for the setae-bearing boletes, *Xerocomus* certainly was the genus

most closely suggesting affinity. When younger stages of these interesting African and Asiatic species become available, it will be possible to decide whether *Boletochaete* actually is related to *Xerocomus*. If the trama has the same structure in young stages as in the adult ones studied by us, this question may be answered affirmatively. If however the young tube walls have a bilateral trama it would seem to us that *Boletochaete* is closer to a group of boletes that though having the external appearance of *Xerocomus*, and in some instances were interpreted as such, actually have bilateral trama, and should be treated as belonging in the genus *Pulveroboletus* in a larger sense. The decision as to whether *Boletochaete* is closer to *Xerocomus* or to *Pulveroboletus* can only be made after young stages of one or all of them have been studied. The examination of the adult stages available would suggest a trama of the *Xerocomus* type, but previous experiences with *Pulveroboletus Ravenelii* convince the writer that in some cases the trama tends to become more uniform in age. In any case, the setae of *Boletochaete* distinguish this genus sufficiently from all known genera of Boletaceae, and certainly justify the erection of a separate genus for these tropical fungi.

## 2. *Phaeogyroporus* Sing. gen. nov.

Boletacearum genus; sporis in cumulo olivaceo-brunneis (inter "Isabella color" et "light brownish olive" Ridgwayi mediis), levibus, breviter ellipsoideis; basidiis haud voluminosis; cystidiis praesentibus, haud exiguis; hyphis fibuligeris; hymenophoro tubuliformi, ad stipitem simpliter adnexo vel distincte depresso, haud decurrente, poris minutis vel mediis, tubulis longiusculis.

The type species is *Boletus Braunii* Bres. sensu nostro as preserved at Farlow Herbarium. Another species belonging here is *Boletus tropicus* Rick sensu nostro as preserved in the Patouillard Herbarium, Farlow Herbarium, under the name of *Boletus crassus*.

The new combinations *Phaeogyroporus Braunii* (Bres. sensu Sing.) Sing. and *Phaeogyroporus tropicus* (Rick) sensu Singer, comb. nov. are proposed.

This genus is close to *Gyroporus* macroscopically, and does not recall *Gyrodon* in this regard; microscopically however, it reminds one of *Gyrodon*, or *Paragyrodon* in more than one character. The spore print was only two years old when first seen by the

writer *i.e.* rather fresh. It is impossible for a *Gyroporus*, even if the improbable should be true that the spores have measurably changed their color during these two years. Spore preparations of species of *Gyroporus* even if kept for many years never attain a color as deep and as olivaceous as shown in our spore preparation of the species we now call *Phaeogyroporus Braunii*. This preparation was obtained by the collector, G. W. Harley. We are convinced that his specimens are genuine *Boletus Braunii* Bres., as described and figured by Bresadola from the Camerouns. However, in studying Agaricales we have found that sometimes the most improbable turns out to be correct, and therefore, maybe overcautiously, we prefer to choose as the type of the new genus not the type of Bresadola's species which we have not seen, but Harley's collection mentioned above. By an unfortunate coincidence, the second species belonging in *Phaeogyroporus*, is known to the writer only by a well preserved specimen in the Patouillard Herbarium under the name *Boletus crassus* which we cannot find in Rick's papers. Yet, this specimen was sent to Patouillard by Rick in 1906, and we think it fits very well in Rick's description of *Boletus tropicus*. Our guess is that Rick discovered shortly before publishing his first account that the name *Boletus crassus* was preoccupied, and therefore changed it. But as authentic material under the correct name is not available, we cannot definitely prove the identity. The same species represented in Patouillard's Herbarium, and collected in Brazil, has also been collected by Harley in Liberia.

### 3. *Xanthoconium* Sing. gen. nov.

Boletacearum genus; sporis in cumulo vegeto luteolis, sub microscopio aureis, levibus, cylindraceis vel fusoido-cylindraceis; basidiis haud voluminosis; cystidiis praesentibus; tramate ditinctissime bilateralis; hyphis haud fibuligeris; hymenophoro tubuloso, simpliter adnato vel adnexo aut frequentius circum stipitem depresso, poris minutis; stipite aequali vel ventricoso, glabriusculo, levissimo, solido; pileo haud scrobiculato; sapore miti; carne immutabili.

The type species is *Gyroporus stramineus* Murr., Bull. Torrey Club 67: 62. 1940. Other species belonging here: *Boletus affinis* Peck, Ann. Rep. N. Y. State Mus. 25: 81. 1873.

The following combinations are proposed: *Xanthoconium*

**stramineum** (Murr.) Sing. comb. nov. and **Xanthoconium affine** (Peck) Sing. comb. nov.

Studies at the type localities, and type studies in the Herbarium of the Agricultural Experiment Station of the University of Florida at Gainesville enabled the writer to obtain the necessary data on the strange group of species described by Murrill and Snell as white spored *Gyropori*, and separated by the latter under the new generic name *Leucogyroporus*. *Leucogyroporus pisciodorus* (Murr.) Snell, the type species of the genus *Leucogyroporus*, actually has what is called "pink" spores *i.e.* the fresh spore print on white paper is "vinaceous fawn," and is a rare variety between "fawn color" and "wood brown" Ridgway. Since there is no appreciable generic character to prevent this species from being incorporated in the pink spored genus *Tylopilus*, and since *Leucogyroporus pisciodorus* is, as the existing types clearly show, nothing else but *Boletus tabacinus* Peck, we think that the correct name for this species is ***Tylopilus tabacinus*** (Peck) Sing. comb. nov. and the genus *Leucogyroporus* would become a synonym of *Tylopilus*. On the other hand, *Leucogyroporus stramineus* (Murr.) Snell is not a *Tylopilus* unless the latter genus is amended drastically. The narrow, golden yellow spores and the smooth, glabrous stipe, the yellow to rusty yellow spore print, and the context which neither tastes bitter nor changes color on exposure, combined with the absence of pits on the pileus, sufficiently separate *Leucogyroporus stramineus* from *Tylopilus*. The characters separating *Tylopilus* from *Boletus sensu stricto* are about as many and as important as the ones separating *Xanthoconium* from *Tylopilus*, and therefore, if *Tylopilus* is considered as a distinct genus (as I think it should) though related to *Boletus*, then, *Xanthoconium* is a third good genus of the same tribe. We want to insist, at this occasion, on our previous statements that there are no boletes with white spores. All species included in the genus *Leucogyroporus* by Snell actually produce a colored spore print, and the indication that the spores were white, probably originated in an authentic spore preparation of Murrill's where the paper stayed white, but, as a careful examination revealed, there was not a single spore on it; it may also have originated with the observation that, under certain circumstances, the single spore

under the microscope *e.g.* in *Tylopilus tabacinus* (Peck) Sing. and *T. Rhoadsiae* (Murr.) Murr. seems to be or actually is hyaline. But this also is the case with spores of *T. felleus* or *T. plumbeo-violaceus*, and as a matter of fact, the spore print is pink in all these species. It is true that the spore print of *Filoboletus* Henn., and possibly *Polyporoletus* Snell is pure white to creamy white. However, as the writer shall show in a paper which is now in preparation, the former is an agaric (Marasmiaceae), and the latter is a *Scutiger*; they therefore cannot be considered as boletes.

#### 4. *Callistosporium* Sing. gen. nov.

Tricholomatacearum genus; pileo hygrophano vel sicco, cuticula ex hyphis repentibus composita; carne tenui; hymenophoro lamelloso, lamellis angustato-adnexis, vel adnatis, vel emarginatis; sporis ellipsoideis, levibus, permultis pigmenti corpusculo purpureo vel atrolilacino aut pigmenti solutione rubro-rosea vel lilacina impletis, membrana inamyloidea, tenui, hyalina instructis; pleurocystidiis nullis; tramate lamellarum regulari, haud amyloideo; stipite centrali, subcartilagineo, tenui; hyphis omnibus fibulis destitutis. Habitatio: Ad basin palmarum et ad ligna.

The type species is *Gymnopilus palmarum* Murr., Bull. Torrey Club 66: 32. 1939. Other species belonging in this genus are: *Collybia Heimii* Sing., Revue de Mycologie 2: 234. 1937, and a species which we discovered in the Herbarium of the Agricultural Experiment Station in Gainesville, Fla., collected and named by W. A. Murrill (as *Psilocybe*) but still unpublished. This species will be described here below.

The following combinations are proposed: *Callistosporium palmarum* (Murr.) Sing. comb. nov.; *Callistosporium Heimii* (Sing.) Sing. comb. nov.

#### *Callistosporium psilocybe* Murr. & Sing. sp. nov.

Pileo uniformiter melleo-subumbrino, "carob brown" (Ridgway) in siccis, hygrophano, levi, glabro, campanulato vel convexo, in siccis centro depresso, in statu vegeto haud plane expanso, 25 mm. lato; cuticula ex hyphis repentibus consistente.—Lamellis pallidis leniterque melleo-tinctis, "carob brown" (Ridgway) in siccis, brevioribus intermixtis, ad aciem erosis, moderate latis, confertis vel confertissimis, adnatis vel emarginatis; sporis 5–6.2 × 3.3–4  $\mu$ , ellipsoideis, poro germinativo destitutis, hyalinis vel roseo-vinaceis quia succo cellulari lilacino impletae sunt, saepe uno vel duobus corpusculis crystalliformibus pigmenti lilaceis intracellularibus ornatis, membrana hyalina et tenui, inamyloidea, levi gaudentibus; basidiis 16.5–26 × 4.6–6.5  $\mu$ , succo hyalino vel lilaceo impletis, saepe guttulis et crystallis lilaceis ornatis, tetrasporis; cystidiolis fusiformibus vel fusioideo-lageniformibus vel basidiomor-

phis, admodum sparsis, hyalinis; acie lamellarum homomorpha, cheilocystidiis nullis; cystidiis veris nullis; tramate lamellarum regulari, ex hyphis subparallelis vel subintertextis haud fibuligeris consistente.—Stipite concolori, levi, glabro, aequali, leniter compresso, subcartilagineo,  $40 \times 5$  mm.—Carne tenui, mellea, subtenaci; hyphis haud fibuligeris; sapore amarissimo.—Habitatio: Ad lignum quercinum putridum in silva frondosa paludosa ("low hammock"). Octobri mense. Rarissime. Juniper Springs, Floridae, U. S. A. Leg. W. A. Murrill.

As for the type species, *C. palmarum*, we find, that by a strange coincidence, an *Agaricus* (*Collybia*) *palmarum* has been described before by V. B. Briganti in his *Historia Regni Neapolitani*, Naples 1848 which may very well be the same fungus. Since Murrill described his species as *Gymnopilus palmarum* Murr., the existence of an earlier *Collybia palmarum* does not invalidate Murrill's name, and in the case Briganti's species should be the same as Murrill's—in spite of a few differences—the name *Callistosporium palmarum* will stand, but the name of the author will have to be changed.

The new genus *Callistosporium* is very remarkable for its peculiar intracellular pigment of the spores and, in some cases, also of the basidia. An additional very important character is the clampless septa of the hyphae. The characters of these fungi do not seem to indicate any relationship with the Coprinaceae (*Stropharioideae*), nor with such pale spored forms as *Psathyrella subcernua* (Schulz.) Sing. comb. nov. (*Agaricus subcernuus* Schulz., *Psilocybe conissans* Peck), or "*Hypholoma*" *Agaves* Maire (*Scotosporioideae*). We therefore think that the lilaceous or purple color of some spores, and possibly a colored spore print should not schematically be considered as a sufficient evidence for eliminating this genus from the Tricholomataceae where its affinities appear to be. It differs from *Collybia* in having no clamp connections, from *Tricholoma* in having intracellular pigment, from *Omphalia* in having non-decurrent lamellae and the center of the pileus depressed only in dried specimens. From all three genera it differs in having colored spores.

##### 5. *Nothopanus* Sing. gen. nov.

Tricholomatacearum genus; pileo rarissime centraliter, plerumque admodum excentrice vel lateraliter stipitato vel affixo, carne molliusculo-subcarnosa in juvenilibus, tenaci in adultis ex hypharum membranae crassitie; sporis in cumulo albis, sub microscopio hyalinis, ellipsoideis vel subglobosis,

nunquam cylindraceis, tenuitunicatis, haud amyloideis; basidiis granulatione carminophila destitutis, cystidiis nullis; tramate lamellarum regulari, haud amyloideo; lamellis plus minusve adnatis vel decurrentibus; stipite breviusculo vel nullo; hyphis fibuligeris; habitatio: ad ligna putrida vel viva.

The type species of this genus is *Agaricus* (*Pleurotus*) *eugrammus* Mont. Other species belonging in this genus as autonomous species or forms of *N. eugrammus* are numerous. The most important ones are *Xerotus guadelupensis* Pat. and *Xerotus vinosofuscus* Bres.

The new combinations ***Nothopanus eugrammus*** (Mont.) Sing. comb. nov., ***Nothopanus guadelupensis*** (Pat.) Sing. comb. nov., ***Nothopanus vinosofuscus*** (Bres.) Sing. comb. nov. are proposed.

Fungi belonging to *Nothopanus eugrammus* either as a synonym, or a form, and others, congeneric with it, have been described in the following genera: *Agaricus*, *Panus*, *Panellus*, *Xerotus*, *Xerotinus*, *Pleurotus*, *Marasmius*. Patouillard seems to have included this group in *Xerotus*, and Murrill, using Reichenbach's nomen novum *Xerotinus*, aside of making *N. eugrammus* a *Panellus*, indicates two American species of the former genus which both belong in *Nothopanus*. We do not think that the generic name *Xerotus*, or *Xerotinus* can be used for any well known group, at least at present. There is no doubt that the type species of the Friesian genus is *Xerotus afer* Fr., and Murrill cites this same species as the type of *Xerotinus*. Lloyd indicates that there is a specimen of this in Sweden, and he gives an illustration of it in Mycol. Notes 7: 1154, fig. 2259. 1922. Without microscopical data, however, all that can be said about this plant, is pure guess work. It may be that it belongs to a species of a well known genus, differing only in abnormally forking gills, a character which, in our opinion, hardly is of generic importance. But there is little likelihood that *Xerotus afer* would eventually turn out to be a *Nothopanus*. The dark color of most of its parts would suggest another group of fungi which usually is called *Xerotus*, but even in this case it is very doubtful whether they are congeneric. The group I have in mind, is *Anthracoephyllum*, as I would prefer to call this genus at present, disregarding the mistake some authors originally made about the color of the spores. Actually, the spores



of all these species (or forms) are hyaline, and what black particles may have been observed, are carbonaceous pigment bodies which dissolve to a characteristic green solution when brought under the microscope in an ammoniacal medium. The spores are ellipsoidal to subcylindric, non-amyloid, smooth, thin-walled; hyphae with clamp connections. Lloyd also states (referring to *Anthracoephyllum*) that "the original idea" (i.e. the type of *Xerotus afer*) "was lost sight of, however, in these additions. . . ." We may add that in including *X. guadelupensis* and *X. vinosofuscus*, and other species, here reunited as *Nothopanus*, Patouillard and Bresadola had still further lost sight of the original idea. Therefore, it has become necessary to distinguish the group centering around *Agaricus eugrammus* Mont. as a new genus.

6. *Smithiomyces* Sing. gen. nov.

Leucocoprincearum genus; pileo levi, pelliculae tenuissimae deterrentibus fragmentis oblecto, sicco, haud squamoso, pellicula ex hyphis atque sphaerocystis Russulacearum fere modo intermixtis consistente; lamellis permultis, liberis, haud attingentibus; sporis albis in massa, minutis, neque amyloideis nec pseudoamyloideis, levibus; carne molli, alba; habitatio: ad humum et ad lignum putridissimum in silvis subtropicalibus vel tropicalibus.

The type species of the genus is *Leucomyces mexicanus* Murr. (*Amanita mexicana* Murr., *Venenarius mexicanus* Murr.).

The new combination *Smithiomyces mexicanus* (Murr.) Sing. is proposed.

This remarkable species and genus has been collected once by Murrill, in Mexico, and many times by the writer in Highlands and Dade Counties of the State of Florida, U. S. A. It differs from all other forms of this family in having the peculiar heteromorous structure of the fragmentary veil on the surface of the pileus as described above. Aside from that, it differs from *Lepiotella* in white spore print, presence of clamp connections, absence of cystidia, dry pileus; from *Lepiota* in having non-pseudoamyloid spores, and from *Cystoderma* in having free lamellae. It reminds one macroscopically of *Amanita*, but is readily distinguished from the Amanitaceae in having regular trama and a combination of size and shape of spores that does not occur in that family. This is most certainly a good new genus. For a moment, we considered using the name *Leucomyces*, but this would have been too

obviously in contradiction with the International Rules (see also Rogers on *Cristella*, Mycologia 36: 78. 1944). Aside from this, it would also be opposed to the intention Murrill had when digging out this pre-Friesian name at this one occasion. He then thought *Leucomyces* Batt. under the rules of the American Code, would be the valid name for what we now call *Amanita*, but later replaced this name by *Venenarius* Earle. Thus *Leucomyces mexicanus* Murr. cannot be the type of the genus *Leucomyces*, but the type must be one of the few species described and figured by Battarra under this generic name. These species, though hardly determinable at present, certainly do not belong to *Smithiomyces* since this latter does not occur in Europe, and none of Battarra's species shows the slightest similarity with it. Consequently a new generic name is needed for *L. mexicanus* with this latter species as type. We are glad to dedicate this genus to Alexander H. Smith whose contributions to American Agaricology during the last decade are among the most outstanding advances in this particular field.

#### 7. *Pyrrhoglossum* Sing. gen. nov.

Cortinariacearum genus; pileo astipitato vel pseudostipite superiore praedito, vel possibiliter in aliis speciebus minus notis brevissime lateraliter stipitato, plerumque asymmetrico, lobato lacerove, rarissime subcirculari integroque; lamellis sporarum massae causa laetissime ferrugineis in adultis; sporis breviter ellipsoideis, ferrugineis, grosse verrucosis, disco levi suprahilari poroque germinativo destitutis; cystidiis veris nullis; cheilocystidiis inconspicuis; tramate regulari, flavo; hyphis fibuligeris; habitatio: ad lignum, in regionibus tropicalibus.

The type species of the genus *Pyrrhoglossum* is *Agaricus* (*Crepidotus*) *pyrrhus* Berk. & Curt., or *Crepidotus pyrrhus* (Berk. & Curt.) Sacc. *Crepidotus laceratus* Pat. from Guadeloupe is a synonym, and so is *Agaricus* (*Crepidotus*) *pyrrhus* var. *leiospora* Berk. and Curt. I have carefully compared all the types concerned, and cannot find any real difference between these plants. The allegedly smooth spores of the variety, actually are just as verrucose as they are in the type form.

The new combination ***Pyrrhoglossum pyrrhus*** (Berk. & Curt.) Sing. comb. nov. is proposed.

This new genus is very well defined by its pleurotoid habit, combined with bright ferruginous warty spores. In fact, the anatomy

of the cuticle, the trama, and the hymenium is the same in *Pyrrhoglossum* and in *Gymnopilus* Karst. (*Fulvidula* Romagnési, *Flammula*, sect. *Sapineae* aut.). The chemical reaction with KOH also is identical in the last named genera. Thus, what *Crepidotus* is to *Ripartites*, *Pyrrhoglossum* is to *Gymnopilus*. There is a natural hiatus between both of these genera, the difference in the spores being more conspicuous in *Ripartites-Crepidotus*, while the difference in the shape of the carpophore is more abrupt in *Gymnopilus-Pyrrhoglossum*. There are analogous pairs in other families, such as *Leucopaxillus* and *Lentinellus*, *Crinipellis* and *Chaetocalathus*, *Clitocybe* and *Pleurotus*. It is true that in some other groups, as for example in the genus *Lentinus*, or in *Paxillus* or *Clitopilus*, there is no abrupt cleavage between pleurotoid and centrally stipitate forms, and it has turned out that their subdivision into centrally and laterally and not stipitate species by Karsten and others did not produce well defined genera. While, as a general rule, we do not think that the above characters can serve as a base for splitting a homogenous genus into two or three genera, we are convinced that the opposite doctrine would be just as wrong. There is evidence that in some cases the presence or absence of the stipe may be the main character distinguishing two related genera, and still these genera would be separated not merely artificially, but according to evolutionary lines. It seems to us that, in the case of *Pyrrhoglossum*, we have to do with an independent line of phylogenetic development particular to the tropics. A practical reason for erecting a new genus is the improbability that anybody trying to determine *Pyrrhoglossum* would look for it in *Gymnopilus*, as is clearly shown by the history of the plants described so far. The affinity of *Gymnopilus* and *Pyrrhoglossum* has been established only on the base of a very detailed microscopical analysis and additional chemical data.

Another species which will probably be transferred to *Pyrrhoglossum* as a second species, is *Agaricus croceosanguineus* Mont. from Chile, also considered to be a *Crepidotus* in citations previous to this.

# AN EXPERIMENTAL STUDY OF ALTERNATION OF GENERATIONS IN *ALLOMYCES ARBUSCULUS*

WINSLOW R. HATCH AND RICHARD C. JONES

## INTRODUCTION

The genus *Allomyces* has been known since 1911 when a single species, *Allomyces arbusculus*, was discovered in India by Butler (1). Although Weston (12) suspected sexuality in a form he isolated at Los Banos, Philippine Islands, as early as 1918, it was not until 1929 that an account of sexuality in this genus was published by Kniep (9). Kniep's work was done on *Allomyces javanicus*, and on what we now know as *Allomyces arbusculus*.

The life cycles of the two species mentioned above and of other species, discovered since and assigned to that section of the genus known as *Euallomyces*, have been a matter of much interest to mycologists. In 1930 Kniep (10) found that a regular alternation of generations existed in *Allomyces javanicus* and in the species now recognized as *Allomyces arbusculus*. He showed that the sexual plant arose from a zoöspore from a resistant sporangium on an asexual plant, while the asexual plant was derived from a zygote or from a zoöspore from a thin-walled zoösporangium on an asexual plant. Kniep's conception of the life cycle was that the sexual plant was haploid in character, the asexual plant diploid, with meiosis occurring in the resistant sporangium. As evidence of this relationship, Kniep presented measurements of the volumes of nuclei in the hyphae of sexual and asexual plants. There was an approximate 1:2 ratio, the actual figures being 1:2.12. This interpretation of the life cycle of *Allomyces javanicus* was confirmed by Sörgel (11) in 1936. He likewise found a close 1:2 ratio between the volumes of nuclei in sexual and asexual plants. He found that this relationship also existed between the nuclei in hyphae of sexual and asexual plants of *Allomyces arbusculus*. Emerson (2) in 1941 found additional support for Kniep's origi-

nal interpretation in evidence derived from his genetic studies. It can probably be concluded, on the strength of the evidence presented above, that in that section of the genus now known as *Euallomyces* there is a regular alternation of generations between a haploid sexual and a diploid asexual plant with meiosis occurring in the resistant sporangium. Hatch (7) questioned this interpretation, suggesting that meiosis occurred in the germination of the zygote. A more careful analysis of his material, to be reported upon in another paper, has convinced him that there is really no evidence that meiosis occurs at zygote germination.

Although it is probably true that there is a *regular* alternation of generations between sexual and asexual plants with meiosis occurring in the resistant sporangium, there is much evidence that there is also an irregular life cycle for at least certain members of the *Euallomyces*. In a species of *Allomyces* collected by Weston in Alabama in 1912 thousands of resistant sporangia zoöspores were germinated, but no sexual plants were seen. Sörgel (11) found that in *Allomyces arbusculus* the zoöspores of resistant sporangia sometimes gave rise to asexual rather than sexual plants. Furthermore, in a comprehensive study of many *Euallomyces* isolates Emerson (2) found that "in some strains R. S. zoöspores gave rise to sporophytic plants so regularly that it was only after repeated germination of resistant sporangia under widely different conditions that sexual (gametophytic) plants were finally obtained." Emerson concluded that "We have a series of forms, grading gradually from those which regularly produce a sexual stage to those which apparently form sexual plants very rarely."—"Exactly what conditions exert a controlling effect on the R. S. zoöspores and determine whether they shall develop into sexual or asexual plants is not at all clear at present. Sörgel (11) noted, however, that when R. S. zoöspores of *A. arbusculus* (*Knicipii*) germinated very soon after emergence from the sporangium they were more likely to produce gametophytes, whereas, after an extended swarm period they frequently formed sporophytes."

In addition to the irregularities noted above there is another: the occasional appearance of resistant sporangia on sexual plants. Hatch, 1934 (7), Emerson, 1937 (2), and Sörgel, 1937 (11), have all noted this phenomenon.

We know that the resistant sporangia on sexual mycelia observed by Hatch (8), were either subtended by male gametangia (which may also subtend female gametangia), or that these resistant sporangia were found on sympodial branches coming off below couplets of gametangia—which resistant sporangia either terminated the growth of the branch or later gave rise to whole chains of gametangia. We also know that zoöspores from these resistant sporangia gave rise to sexual plants (Hatch, 8). But this is about all that is known of these resistant sporangia.

Emerson has pointed out: "it should be noted that nothing definite is known concerning the adjustments in chromosome number which must necessarily occur in conjunction with the various departures from the regular life cycle in *Euallomyces*." It was our feeling that, while these adjustments may occur, the determining factors were largely physiological.

This feeling was not without experimental support. In 1938 Tupper,<sup>1</sup> working with *Allomyces arbusculus*, discovered that resistant sporangia from asexual plants grown on maltose-peptone agar gave rise to different products when introduced into a full-strength maltose-peptone solution than when they were inoculated into sterile snow water to which small bits of hemp seed had been added. The plants that developed from the zoöspores of the resistant sporangia cultured in the maltose-peptone solution were exclusively asexual, whereas those that developed from the zoöspores of resistant sporangia cultured in the sterile snow water were preponderantly sexual. In the sterile snow water cultures the only asexual plants observed were those that developed on the hemp seed itself. The resistant sporangia involved in these experiments were genetically similar and were dried for the same length of time (15 days) in small agar blocks cut out of the parent-culture. Under the conditions of this experiment nutrition certainly appeared important in determining the sexual-asexual nature of the products of resistant sporangia.

In other experiments conducted at this time the resistant sporangia were dried for longer periods, and it was noted that whereas the resistant sporangia that had been dried for but 15 days pro-

<sup>1</sup> Stewart Tupper, unpublished notes of work done with the senior author in the Department of Botany, Dartmouth College.

duced asexual plants in a maltose-peptone solution, resistant sporangia dried for longer periods gave rise to fewer and finally to no asexual plants in the same solution. From these experiments it appeared that the amount of drying experienced by resistant sporangia was another important factor in determining the sexual-asexual nature of the products of resistant sporangia.

#### TECHNIQUE

The source of material for these studies was air-dried asexual plants from water cultures of *Allomyces arbusculus*, North Carolina strain. This material, dried since October 5, 1939, was recultured on hemp seed in sterile distilled water December 22, 1942. The asexual plant was brought into pure culture by inoculating maltose-peptone agar plates with single hyphae and by subculturing when freed of contaminants.

To obtain resistant sporangia whose number would always be approximately equal in each bit of inoculum, whose ages were known even to the day, and whose genetic constitution was the same, the following procedure was devised:

Asexual plants were started on fresh maltose-peptone agar plates. On the bottom of these plates several radially-arranged strips of gummed paper were affixed. By marking the extent of each day's growth on these strips, the daily growth of the fungus could be recorded. Growth rings, as was to be expected, appeared in these cultures. These rings, which have been observed by all workers with the fungus and which have been ascribed to diurnal temperature fluctuations by Hatch (6), were observed to follow a daily rhythm. But these growth rings were not always sharp and distinct because the diurnal fluctuations were not always sharp, and so it was found very helpful to have this additional record of the growth of the fungus. When the fungus had grown out towards the edge of the Petri dish, small agar discs were cut from each growth ring. These discs were cut by means of a wire loop of the type commonly used for bacteriological transfers. This loop was bent at right angles to the handle and cuttings were made by simply forcing the loop into the agar. Such a loop may be bent to cut discs of any desired size; those in this work were

approximately 1.5 mm. in diameter. The discs were allowed to air-dry on sterile slides in sterile Petri dishes.

#### PRELIMINARY EXPERIMENTATION

In preliminary experimentation designed to perfect technique, it was discovered that resistant sporangia which had attained an age of less than four days were incapable of throwing viable zoöspores. This, incidentally, was true for the resistant sporangia that were left undried, as well as those that were subsequently dried. This being the case, the youngest resistant sporangia used in our experiments were four days old; the oldest, eleven days old. This gave us a series in which the resistant sporangia were of eight different ages.

Although three-day-old resistant sporangia did not throw viable zoöspores during the progress of our experiments, it was determined that they were uncollapsed and possessed thick walls. Their contents, however, were generally coagulated in larger or smaller spherical masses, and in general the color of their walls was darker or a blacker brown than was the case in older resistant sporangia. It was further noted that in any growth ring the resistant sporangia were more numerous in the flush of reproductive activity and that the zoösporangia conversely were more numerous in the zone of light reproductive activity or on the threshold of this zone.

In these preliminary experiments it was also discovered that in agar discs dried for 48 hours, the thin-walled zoösporangia and the hyphae showed definite signs of collapse, and of incipient disintegration, and when tested in culture, it was established that all asexual material was non-viable. This is in agreement with Kniep's (10) observation that in agar cultures, dried from one to three days, only the zoöspores of the resistant sporangia remain viable. To be absolutely certain of our methods the inoculum was dried for six days before making the first test. We have every confidence, therefore, that plants resulting from this inoculum were all products of zoöspores from resistant sporangia.

Preliminary experimentation also helped to establish the fact that swarming occurred from twelve to twenty plus hours after the inoculum was introduced into the cultures. It was further deter-



Concentration Maltose Peptone	Age attained by Resistant Sporangia before being dried (in days)									Ave. % Sex.	Length of Drying Period
	4	5	6	7	8	9	10	11			
Full Strength	8	9	10	14	11	10	11	12		10.6	6 Days
1/25 Dilution	95	100	100	100	100	99	98	100		99	
1/50 Dilution	100	100	100	100	100	100	100	100		100	
Full Strength		27		32		30				29.7	12 Days
1/25 Dilution		100		100		100				100	
1/50 Dilution		100		100		100				100	
Full Strength	65	66	69	67	70	66	64	66		66.7	18 Days
1/25 Dilution	100	100	100	100	100	100	100	100		100	
1/50 Dilution	100	100	100	100	100	100	100	100		100	
Full Strength		100		100		100				100	24 Days
1/25 Dilution		100		100		100				100	
1/50 Dilution		100		100		100				100	
Full Strength	100	100	100	100	100	100	100	100		100	30 Days
1/25 Dilution	100	100	100	100	100	100	100	100		100	
1/50 Dilution	100	100	100	100	100	100	100	100		100	

TABLE I. Percentage of sexual plants derived from resistant sporangia dried for 6, 12, 18, 24 and 30 days, and subsequently committed to a maltose-peptone solution and to 1/25 and 1/50 dilutions of the same solution.

mined that the plants derived from swarming R.S. zoöspores did not form their reproductive structures before the 36th hour after inoculation and did not discharge their products before the 38th hour. The first plants of the second generation, *i.e.*, the plants derived from zygotes, if the first generation was sexual, or from

zoöspores, if the first generation was asexual, could not at the very earliest begin to germinate before 38 hours after inoculation. It was further determined that this second generation material could not grow to the point where it produced reproductive structure until 54 hours after inoculation. With these facts at hand, it was possible to develop a schedule which made certain that no second generation plants were included in observations upon, or counts of, first generation material.

The inoculum was removed from all dishes 12 to 20 hours after inoculation so no additional zoöspores could be discharged. At this time one cc. of solution with its swarmers was transferred from the 50 mm. Petri dish in which the swarming occurred to a 100 mm. Petri dish containing 19 cc. of the same medium. By the use of this dilution technique it was possible to make more accurate counts. These counts were always made before more than 50 hours had elapsed. Thus, there could be no doubt that whether the plants were sexual or asexual they were certainly derived from zoöspores from resistant sporangia.

In earlier experiments dealing with different concentrations of media, a maltose-peptone solution was used as the rich nutrient and distilled water with minute bits of hemp seed as the weak nutrient. Since the hemp seed medium was not a simple dilution, and since one could not be sure of precisely what the hemp seed contributed, it was decided to try different dilutions of a maltose-peptone solution. It was also found that plants would develop rather well and produce good reproductive structures in these dilutions.

Contamination of our cultures proved to be a problem only in the case of the full-strength maltose-peptone solution, but even here it was found that it could be avoided by showing great care in the handling of the inoculum, in the inoculation itself, and in the subsequent transfer of swarmers. This preliminary experimentation also showed that contamination could be controlled by the omission of peptone from the media or by the treatment of the dried inoculum with 95 per cent alcohol for thirty seconds prior to the inoculation. Although these techniques did not seem to affect the number or the quality of the products of resistant sporangia, it was thought best not to use them because they might introduce

variables. In actual practice it was found unnecessary to use these precautions if care was taken in the handling of the cultures.

#### EXPERIMENTATION

To determine the effect, if any, of the drying of resistant sporangia upon the sexual-asexual ratio of their products, material from four to eleven days of age was dried for six days, twelve days, eighteen days, twenty-four days and thirty days, and subsequently committed to culture. To determine whether the nutrient in the cultures in which the resistant sporangia dehiscid, the zoöspores swarmed, and the germling grew, had any effect on the sexual-asexual ratio of the resultant plants, resistant sporangia were inoculated into a full strength maltose-peptone solution and into two dilutions: a  $\frac{1}{25}$  dilution and a  $\frac{1}{50}$  dilution.

The actual experimental procedure consisted of setting up three different culture series, one series for the full-strength maltose-peptone solution and one for each dilution. Each series was made up of eight 50 mm. Petri dishes. Resistant sporangia of eight different ages, ranging from four through eleven days, were inoculated into each of these three series.

The most accurate method for detecting swarming was found to be examination under a compound microscope equipped with a dark field. This method was quick and certain. A magnification of 100 times was found highly satisfactory for this work.

As soon as swarming was noted, a single cc. of medium, together with its swarmers, was transferred from the 50 mm. Petri dishes to 19 cc. of a similar medium in a 100 mm. Petri dish. This was done in each instance with a sterile pipette. This dilution method enabled more accurate counting and examination of developing germplings.

As has been indicated already, the first reproductive structures began to develop on the young plants in about 36 hours, but characteristic pigmentation of the male gametangium, the best single character for the certain identification of sexual plants, did not become distinct for some hours later, so the examination and counting of the plants was postponed until 45 to 50 hours after inoculation. At this time the plants were examined for the presence of either zoösporangia and/or resistant sporangia, on the one hand,

or gametangia, on the other. As has been intimated, the recognition of sexual and asexual plants presented no particular difficulty. The color of the male gametangium, along with the arrangement and shape of the gametangia, made the identification of the sexual plants a reasonably simple matter. The lack of color, the arrangement and shape of zoösporangia, and/or resistant sporangia made the recognition of asexual plants easy. The sexual-asexual ratio was determined by making counts of each type. Here the practice was to count all plants if there were less than 100. If there were more, only the first 100 were counted and these sums were then converted to percentage of sexual plants.

Concentration Maltose Peptone	Length of Drying Period of Resistant Sporangia				
	6 Days	12 Days	18 Days	24 Days	30 Days
Full Strength	10.6	29.7	66.7	100	100
1/25 Dilution	99	100	100	100	100
1/50 Dilution	100	100	100	100	100

TABLE II. Average percentage of sexual plants derived from resistant sporangia dried for 6, 12, 18, 24 and 30 days, and subsequently committed to a maltose-peptone solution and to 1/25 and 1/50 dilutions of the same solution.

The selection of plants, of course, was always at random. Since the swarmers were of approximately the same age, accurate counts were facilitated by the fairly simultaneous development of reproductive structures. The fact that the young plants dispersed themselves rather evenly over the bottom of the Petri dish made their separate consideration possible. The results of these counts are embodied in tables I and II.

#### DISCUSSION

From a study of tables I and II it is evident that while the resistant sporangia in each experiment varied in age as much as 8 days, there still was no consistent difference or trend in the sexual-

asexual ratio of their products. The age attained in culture before they were dried did not seem to be very important except as it figured in elapsed time. The significant trends are to be seen in the sexual-asexual nature of the plants derived from resistant sporangia that had dried 6 days as opposed to those that had dried 12, 18, 24 or 30 days.

If (tables I and II) we compare the data presented for resistant sporangia dried for 6 days with that of resistant sporangia dried for 12 days, it is apparent that the effect of the additional drying is to increase the proportion of sexual products. If we compare, in turn, the data of resistant sporangia dried for 12 days with that of resistant sporangia dried for 18 days, it becomes apparent that this same trend continues. If we compare the products of resistant sporangia dried for 18 days with those of resistant sporangia dried for 24 days, we find that all products of resistant sporangia dried for 24 days are sexual, irrespective of the nutrient in which they developed. Resistant sporangia dried for 30 days continued to demonstrate this completely sexual condition.

Under the conditions of the experiment all products of resistant sporangia became exclusively sexual somewhere between the 18th and 24th day of drying. The precise number of days is of no consequence, because it is apparent that the number will vary, with temperature, size of inoculum, etc. Furthermore, the threshold for material dried without the protection of agar may well be different.

That nutrition is also important in determining the sexual-asexual nature of the products of dried resistant sporangia is apparent from a comparison of the results bearing on the plants developed in the three different concentrations of maltose-peptone solution. In all instances where the medium exerts a demonstrable influence on the products of the resistant sporangia, the rich medium seems to throw the products in an asexual direction. Under the conditions of the experiment it is to be noted that plants derived from zoospores of resistant sporangia are predominantly asexual in rich nutrient media when the resistant sporangia have been dried for 6 and 12 days and that a large proportion are still asexual when the resistant sporangia have been dried 18 days. Only when resistant sporangia have been dried 24 days or longer

is the rich medium unable to affect the sexual-asexual nature of their products. In general it seems that the drying of resistant sporangia works in opposition to rich conditions of nutrition upon the ultimate expression of the sexual-asexual nature of the products of resistant sporangia.

#### CONCLUSION

It now seems possible to conclude that physical phenomena (dehydration and hydration) and possibly physiological conditions (nutrition) are of critical importance in determining the sexual or asexual nature of plants derived from *R. S.* zoöspores.

It would also seem that if we accept Knip's (10), Harder and Sörgel's (4), Sörgel's (11), and Emerson's (2) explanation that meiosis occurs regularly in the resistant sporangium, and if we exclude nuclear fusions during the swarming or germination of the *R. S.* zoöspores, a possibility, but one that we find highly improbable, then our experiments can only be interpreted as carrying the clear implication that if we have not found a means of inhibiting meiosis (by lack of drying or by rich nutrient) we have found a way of creating a haploid sporophyte.

Whether in a given bit of inoculum meiosis is general in each resistant sporangium, whether it occurs only in certain resistant sporangia, or whether it is inhibited in all resistant sporangia, clearly seems to depend upon the amount of drying the resistant sporangia experience, or it depends upon the nutrient of the media in which they undergo final maturation (zoösporogenesis) and dehiscence. We do not know, of course, anything about what is implied in "drying" or "rich nutrient."

These experiments finally suggest that the common practice of drying resistant sporangia for "several weeks" before introducing them into water or weak nutrient culture may be responsible for the fact that the products from resistant sporangia were predominantly sexual in our earlier work (Hatch 1933-38).

#### SUMMARY

*Allomyces arbusculus*, North Carolina strain, was brought into culture and was experimented upon in an effort to determine what

effect drying and nutrition might have on the sexual-asexual ratio of the products of its resistant sporangia.

Previously unreported methods of culture and examination are described.

Experimental results demonstrate that when resistant sporangia are air-dried for 24 days the products of these sporangia are exclusively sexual and this condition will remain unchanged even when the resistant sporangia are brought to dehiscence in rich nutrient. The products of resistant sporangia dried for 18 days are predominantly sexual, but not exclusively so when cultured in rich nutrient. The products of resistant sporangia dried 12 days will be predominantly asexual in rich nutrient and the products of resistant sporangia dried only 6 days will not only be predominantly asexual in rich nutrient, but will produce some asexual plants in weak nutrient.

It is concluded that drying and nutrition affect the sexual-asexual ratio of the products of resistant sporangia.

It is suggested that the common practice of drying resistant sporangia for several weeks before inoculating into water or weak nutrient cultures may have been largely responsible for the fact that the products of resistant sporangia have, heretofore, been reported as being preponderantly sexual.

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## A SPECIES OF ARTHROBOTRYS THAT CAPTURES SPRINGTAILS

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(WITH 6 FIGURES)

Of the predaceous fungi, numbering about 61, that have been made known both with respect to the vegetative stage active in capture of animals, and with respect to at least one reproductive phase sufficiently distinctive to provide a basis for identification, 3 are recognized as preying mainly on rotifers, 5 as preying habitually on testaceous rhizopods, 24 as preying habitually on *Amoebae*, and 29 as preying habitually on nematodes. Although offering an obvious analogy with the insectivorous phanerogams, the fungi hitherto reported to subsist through capture of motile animals have in no instance been found specially adapted for preying on insects. Such adaptation might, indeed, seem hardly possible, since even the smallest of the more familiar insects appear rather large in comparison with organisms of truly microscopic dimensions. Nevertheless, a hyphomycete has recently been observed, which, though no more robust than the several nematode-capturing forms closely related to it, is unmistakably adapted to prey primarily on insects, and under natural conditions presumably is given wholly to a predaceous mode of life.

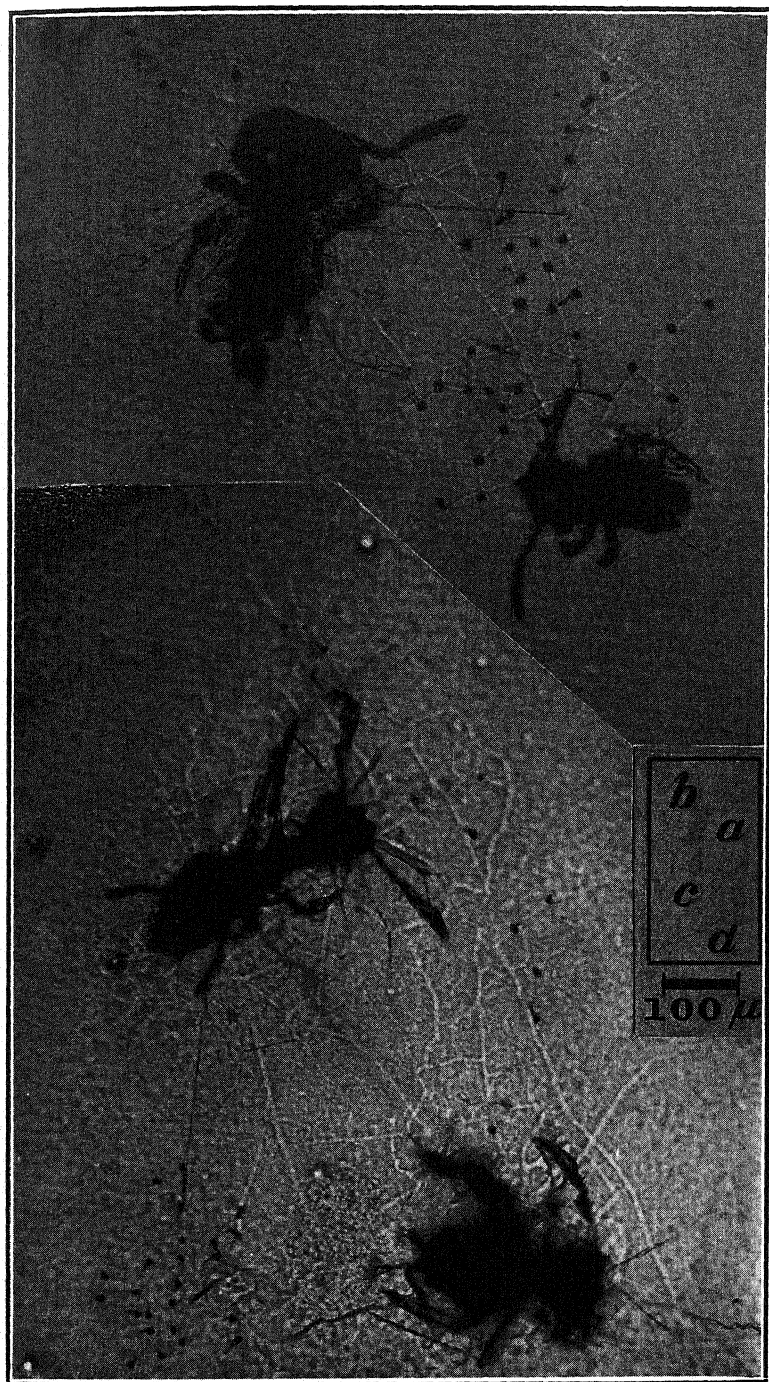
The hyphomycete in question made its appearance in 14 Petri plate cultures planted on Sept. 18, 1943, with discolored rootlets of *Polygonum pennsylvanicum* L. freshly collected from moist ground near a brook in Arlington, Va. Most of the cultures had previously been used in growing *Pythium ultimum* Trow and *P. vexans* de Bary, and thus were thoroughly permeated with oomycetous mycelium when the final planting was made. The few cultures

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wherein sterile medium—maizemeal agar of rather soft consistency—was used soon became permeated likewise with pythiaceus mycelium, as *P. palingenes* Drechsl. promptly grew out from each of the discolored rootlets. Development of bacteria in moderate quantity permitted gradual multiplication of rhizopods and eelworms, which, in turn, led to development of fungi subsisting on these animals. Examinations made at weekly intervals during the month of October revealed the 3 widespread nematode-capturing species *Arthrobotrys oligospora* Fres., *Dactylella ellipsospora* Grove, and *Dactylaria candida* (Nees) Sacc., variously intermixed with the 7 allied nematode-capturing forms I have described (2) under the binomials *A. conoides*, *A. musiformis*, *A. dactyloides*, *Dactylella bembicodes*, *Dactylella gephyropaga*, *Dactylaria brochopaga*, and *Dactylaria thaumasia*. Except that their conidiophores occasionally interfered with pedestrian locomotion, these fungi did not harmfully affect the concomitant development of a minute species of springtail often encountered on decaying plant materials that have been kept for some time under moist conditions. This springtail, whose length was usually found varying from 125  $\mu$  in small individuals to 350  $\mu$  in large individuals, and whose width was equivalent generally to one-third or two-fifths of its length, has been identified as a member of the genus *Sminthurides* (subgenus *Sphaeridia*) very similar to *Sminthurides* (*Sphaeridia*) *serratus* Folsom and Mills (6); it belongs, therefore, in the family Sminthuridae of the order Collembola.<sup>2</sup> If the earlier examinations gave no evidence that the insect was suffering any mishap, an examination made on November 1, when in most cultures it had attained numbers ranging from 50 to 100, showed many dead specimens grouped in small areas near the decaying roots added 44 days previously. A somewhat clustered arrangement of the dead insects and the constant proximity of many erect columnar processes (FIG. 1-4) indicated a predaceous fungus as the agent of destruction.

<sup>2</sup> For identification of this difficult insect, I am greatly indebted to Miss Grace Glance of the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, Washington, D. C. A general idea of its appearance may be gained from illustrations of related springtails given by Comstock (1: p. 229, fig. 236), by Folsom and Mills (6: figs. 19, 84), and by Mills (8: p. 123, fig. 13).

During the ensuing 10 days numerous additional groups of columnar processes appeared; the new groups being produced, for the most part, at increasingly greater distances from the root material whence the first groups had originated. This more widespread development was accomplished by radial extension of rather narrow, straightforward, hyaline, septate, prostrate hyphae that for relatively long distances showed only meager branching of commonplace character. However, at intervals these long hyphae would widen perceptibly and would give off several branches close together and at angles approaching a right angle. Not far from their respective origins, the branches, which in the beginning ran parallel with one another, would abruptly change their direction of growth to anastomose with one of their fellows, or would give off one or more secondary branches to accomplish a similar end; thereby forming a hyphal network prostrate on the surface of the substratum. Many of the segments composing the network then would send up, individually, an erect process consisting of a stout stalk-like basal cell together with a wider distal cell, ovoid or prolate ellipsoidal in shape (FIG. 5, *A*; *B*, *a-f*; *C*, *a-g*; FIG. 6, *A*, *a-p*). The distal cell, in all instances, soon secreted a relatively large quantity of a colorless adhesive liquid. In cultures well protected against evaporation for a few days, the adhesive liquid often appeared as a glistening globular droplet between 15 and 20  $\mu$  in diameter (FIG. 5, *A*, *a-m*); and it may be presumed that a guttular form is generally characteristic of the newly elaborated adhesive mass. However, more usually the body of adhesive exudate appeared as a rather strongly collapsed, irregularly lobate envelope surrounding the distal cell (FIG. 5, *A*, *n, o, s, t, v, x, z*; *B*, *a-f*; *C*, *a-g*; FIG. 6, *A*, *b, c, f, g, i, j, k, n, o, p*). When the columnar process was brought into a prostrate position, as frequently happened, the adhesive envelope would flatten out over the substratum and reveal a very thin peripheral film (FIG. 5, *A*, *n, p*; FIG. 6, *A*, *a, d, e, h, l, m*). Through secondary development a new erect process was often sent up from the base of a procumbent stalk (FIG. 5, *A*, *o, q*) or from a prostrate distal cell (FIG. 5, *A*, *u, v*); or a new adhesive process would arise not only from an older prostrate stalk but also from the glandular cell originally surmounting it (FIG. 5, *A*, *r, s, t*); or two new adhesive processes would arise from a

FIG. 1. *Arthrobotrys entomophaga*.

prostrate glandular cell (FIG. 5, *A*, *w*, *x*, *y*), one or the other, perchance, eventually in turn giving rise from its distal cell to an adhesive process of tertiary origin (FIG. 5, *A*, *z*).

The manner in which the erect processes operate as predaceous organs in the capture of springtails was immediately obvious from their general similarity to the intramatrical predaceous processes of *Dactylella ellipsospora* and of the two allied nematode-capturing hyphomycetes I have described as *Dactylella asthenopaga* (2) and *Dactylaria haptospora* (3).<sup>3</sup> Borne aloft at a height usually of 10 to 15  $\mu$  the distal glandular cell is well placed for adhering to the ventral side of the low-bodied prey, or to its legs. The abundant elaboration of sticky exudate beforehand would seem important in assuring, at the very outset, such extensive adhesion that the effort of the insect to free itself by immediate use, more especially, of its powerful spring, will prove ineffectual. Owing to the close arrangement of the erect processes in groups, several of them probably often adhere to the animal at the same time, thereby fastening it down all the more securely.

Except for a frequently abnormal posture of body and appendages, which was obviously attributable to their struggles to escape, captured springtails for several days offered no marked departure in outward appearance when viewed under a microscope of low magnification; though closer examination at this time invariably showed the insects being permeated throughout with mycelium. Apparently, as in the 3 nematode-capturing hyphomycetes provided with similar predaceous organs, penetration is accomplished by the glandular cells most directly operative in effecting capture. Entrance of the fungus on the ventral side of prey was not brought under observation successfully. In instances where the fungus entered by way of an outstretched leg or sprawling antenna (FIG. 6, *B*, *a*) appearances indicated that the adhering glandular cell thrusts a narrow outgrowth through the thin integument, and then gives rise inside to a number of short swollen cells. From these swollen cells filamentous hyphae somewhat wider even than the hyphae

<sup>3</sup> In view of their passive operation the predaceous organs here concerned invite comparison also with the stalked glands employed for capturing insects by 3 carnivorous phanerogamic plants (7), *Byblis linifolia* Salisb., *B. gigantea* Lindl., and *Drosophyllum lusitanicum* Lk.



FIG. 2. *Arthrobotrys entomophaga*.



making up the prostrate network outside are extended to permeate the fleshy interior with a copiously ramifying assimilative mycelium. Rather marked irregularities in thickness of hyphae may appear at articulations between joints of the appendages (FIG. 6, B, b; C).

The assimilative hyphae are distinguished by greater width not only when they are found in captured springtails but also when they occur in nematodes. Invasion of nematodes came under observation with some frequency in several cultures in which mites had borne down many newly developed predaceous processes, thereby bringing numerous adhesive cells into prostrate positions where eelworms might readily brush against them. Division of the assimilative hyphae into rather short and often somewhat inflated segments gave the mycelium formed within invaded specimens of *Plectus parvus* Bastian, the species most frequently found serving as prey, a curiously knotted appearance (FIG. 5, D) not hitherto noted in any fungus habitually given to capture of eelworms. When assimilative mycelium developed within eelworms gave rise to predaceous apparatus, it produced erect columnar stalks (FIG. 5, D, a-h), each bearing aloft a glandular cell,—in fine, it produced apparatus primarily suitable for capturing springtails rather than for capturing nematodes.

Although in all hyphomycetes now known to prey habitually on nematodes the assimilative hyphae transfer their protoplasmic contents backward into the external mycelium by way of the channel of invasion, those of the present fungus were sometimes found erupting through the integument of an eelworm to extend new mycelial filaments externally without reference to the path of ingress (FIG. 5, D). Apparently eruption may likewise take place through the integument of a captured springtail, for not infrequently long aerial filaments were seen festooned from the dorsal surface of an immobilized insect like threads of a very scant cobweb (FIG. 1, b, c, d). However, as many captured springtails never showed any arachnoid development, there is reason to believe that the protoplasm elaborated by the fungus from the fleshy materials of its usual prey is for the most part withdrawn backward into the external mycelium. The elaborated protoplasm, in any case, makes possible continued growth of long filaments ex-

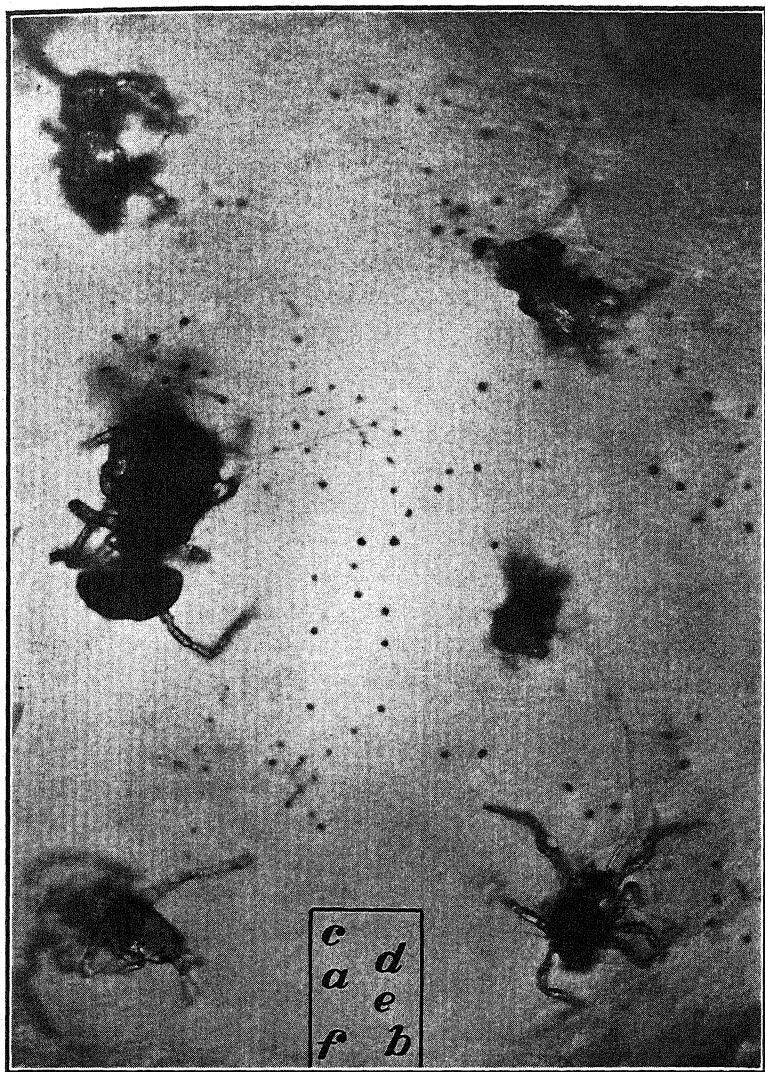


FIG. 3. *Arthrobotrys entomopaga*.

ternally and development on these filaments of additional groups of predaceous organs in the manner already described.

Indeed, in the cultures studied, almost all of the nourishment obtained from captured animals must have been expended in production of mycelial hyphae and predaceous organs—an expenditure



that might have been more profitable if the meager supply of available insects had not soon become exhausted. Only 3 of the 14 cultures showed any reproductive development, and in these 3 cultures only 10 conidiophores could be found, half of which were used in preparing drawings (FIG. 6, *D-G*). Owing to early evanescence of the long hyphal connections it was impossible in most instances to make out with certainty whether the conidiophores belonged to the same fungus as the clustered adhesive organs, though from the beginning both the conidial and the insect-capturing apparatus could be recognized as pertaining to some member of the predaceous series of hyphomycetes. In one instance, fortunately, hyphal anastomoses in proximity to membranous remains of several adhesive cells (FIG. 6, *D*, *a-f*) permitted easy recognition of the subjacent mycelium as consisting of an old insect-capturing hyphal network; a swollen living cell (FIG. 6, *D*, *g*) from which the solitary conidiophore arose being very clearly distinguishable as a glandular cell of the kind operative in capture of springtails.

The reproductive apparatus thus revealed in its proper connection did not conform at all closely to expectations suggested by the morphology of the predaceous parts. Among the nematode-capturing hyphomycetes now known, the closest approximation to the hyphal networks of the present fungus is found in the more or less scalariform networks of *Dactylella gephyropaga*, a species producing large pluriseptate conidia on robust conidiophores. Pluriseptate conidia are likewise produced by the 3 nematode-capturing species, already enumerated, whose predaceous organs show most resemblance to those employed in capture of springtails. Then, too, somewhat robust dimensions of reproductive parts might be inferred from the relatively large size of the prey; for though the species of springtail captured may be small in comparison with the more familiar types of insects, it is large in comparison with the rhizopods and eelworms habitually taken by other terricolous fungi of predaceous habit. Contrary to all presupposition founded on analogy, both the conidiophores and the regularly uniseptate conidia borne on them in clusters were of decidedly modest proportions,—the whole apparatus, indeed, having dimensions not greatly different from those of the congeneric form which I re-

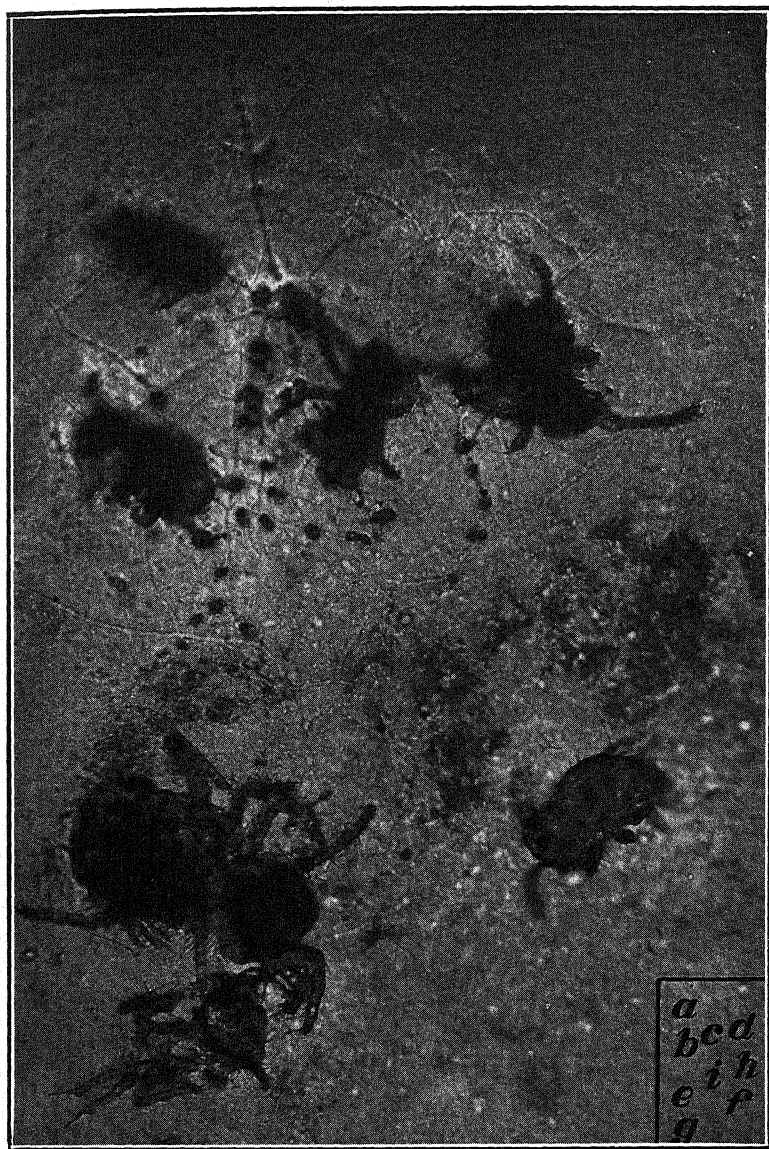


FIG. 4. *Arthrobotrys entomopaga*.

cently described (5) as *Arthrobotrys cladodes* var. *macroides*, and which with respect to its aerial reproductive structures must be reckoned among the smallest of the nematode-capturing hyphomy-

cetes. As the conidia were attached on rather long sterigmata their arrangement in clusters resembled the loose capitate arrangement prevalent in *A. musiformis*, whose much sturdier conidiophore likewise is abruptly subramose at its tip. Resemblance to *A. musiformis* was especially manifest during early stages of development, when only a single conidial cluster was present (FIG. 6, *E*, *a*, *x*). In most of the 10 conidiophores that came under observation, production of the first conidial cluster had obviously been followed by renewed apical growth and repeated sporulation, since they bore aloft 2 (FIG. 6, *D*, *h*, *y*, *z*; *E*, *b*, *y*, *z*; *F*, *a*, *b*) or 3 (FIG. 6, *G*, *a*-*c*) spore clusters and thus offered marked contrast to the strictly monocephalous condition characteristic of *A. musiformis*. As this repeated production of conidia took place when sporulation was exceedingly scanty—so scanty that under comparable circumstances neither *A. superba* Corda nor *A. oligospora* nor *A. conoides* would ordinarily have formed more than a single cluster of spores—there is excellent reason to presume that the fungus has a very strong tendency toward repeated elongation of its conidiophores with concomitant development of conidial heads in prolonged succession. The merit of this presumption has not been confirmed so far by observations on pure cultures, as my attempts to isolate the fungus by aseptic transfer of conidia directly from the conidiophore to a sterile agar medium were all unsuccessful. Yet even without further knowledge of more prolonged development, the reproductive apparatus here discussed appears different from that of any species of *Arthrotrrys* hitherto made known. It seems appropriate, therefore, to present the insectivorous fungus as a new member of that genus, under a specific name compounded of two words meaning, respectively, "insect" and "trap."

***Arthrotrrys entomopaga* sp. nov.**

Mycelium effusum; hyphae steriles generis vulgaris longae, filiformes, incoloratae, mediocriter septatae, 2-3  $\mu$  crassae, saepe repentes et magna ex parte parvulum ramosae sed hic illic aliquantulum latescentes et ramos repentes 3-6  $\mu$  crassos crebre emittentes qui in rete coeunt et ramusculos tenaces erectos ferunt; ramusculis tenacibus vulgo bilocularibus, cellula inferiore cylindrata vel sursum attenuata, plerumque 7-17  $\mu$  longa, 2-5  $\mu$  crassa, cellula superiore quasi ovoidea, 8-13  $\mu$  longa, 4.5-8  $\mu$  crassa, involucro glutinis primum sphaerali mox collapsio circumdata, itaque ad insectum

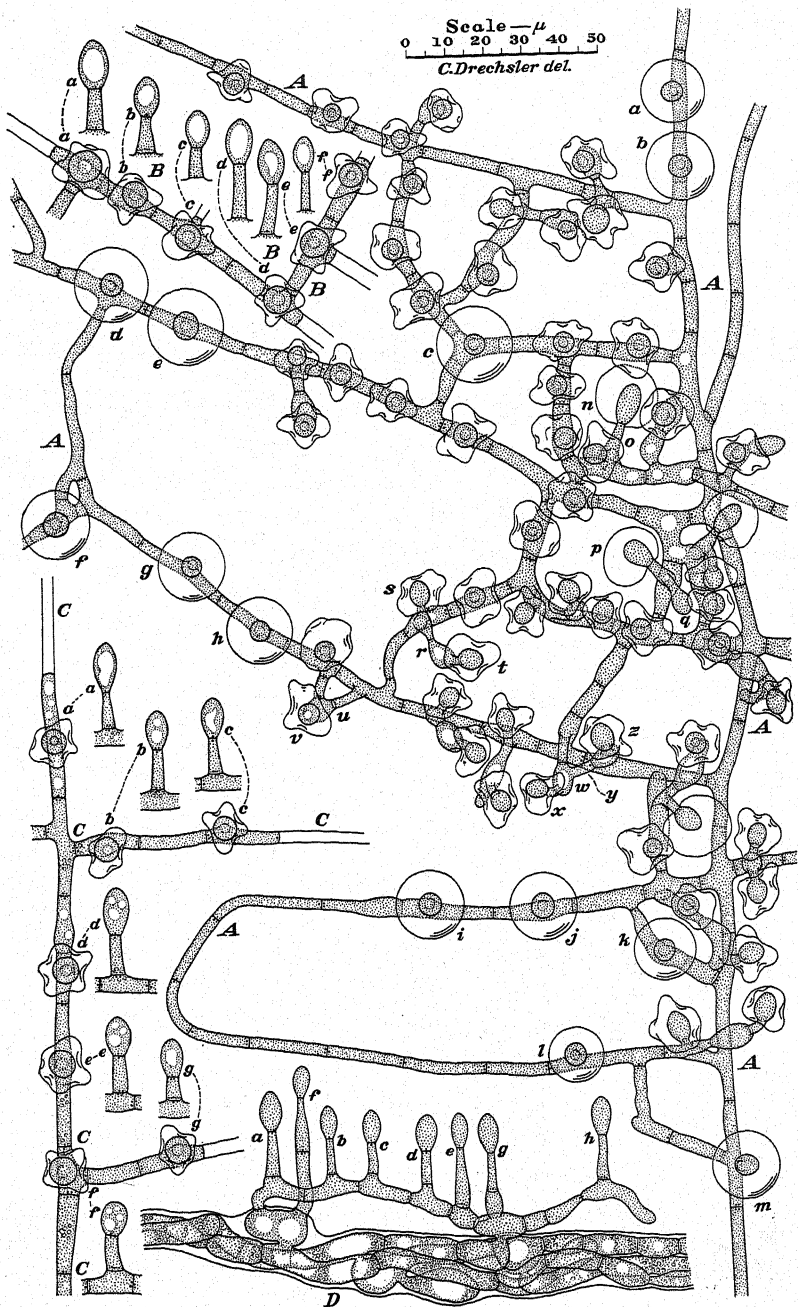
minutum inhaerente, hyphas ramosas  $4-8\mu$  crassas in animal captivum intrudente quae carnem exhauriunt. Hyphae fertiles erectae, incoloratae, pauciseptatae,  $75-175\mu$  altae, basi  $3-4.5\mu$  crassae, sursum circa  $2.5\mu$  crassae, apice paulum inflatae, ibi  $3-8$  sterigmatibus simplicibus vel furcatis  $2-7\mu$  longis instructae, itaque  $3-10$  conidia in capitulum laxum ferentes, denique identidem apice repullulantes alia capitula sporarum deinceps gerentes; conidiis hyalinis, cylindratis vel clavatis, apice rotundatis, basi vulgo aliquid attenuatis et minute pedicellatis,  $15-28\mu$  longis,  $4.5-5.5\mu$  crassis, uniseptatis, cellulis ferme quasi aequalibus tamen cellula inferiore saepe paulo longiore quam cellula superiore.

Insecta minuta specie *Sminthuridarum* (Collembola) etiam vermiculos nematodeos praecipue *Plectum* parvum capiens consumensque habitat in radicibus putrescentibus *Polygoni pennsylvanici* in Arlington, Virginia.

Mycelium spreading; the ordinary vegetative hyphae long, filamentous, colorless, septate at moderate intervals, mostly  $2-3\mu$  wide, often creeping on the surface of the substratum and over rather long distances only sparsely branched, but at intervals widening locally and from the widened portions giving off prostrate branches, mostly  $3$  to  $6\mu$  wide and spaced  $10$  to  $40\mu$  apart, which unite by anastomosis into a network and thereupon give rise to numerous erect aerial predaceous organs; these organs usually uniseptate, the lower cell stalk-like, cylindrical, or tapering upward, mostly  $7$  to  $17\mu$  long and  $2$  to  $5\mu$  wide, supporting aloft an ovoid or prolate ellipsoidal distal cell usually measuring  $8$  to  $13\mu$  in length by  $4.5$  to  $8\mu$  in width and soon becoming surrounded by an envelope of adhesive secretion effective in holding any suitable roaming springtail, which then is invaded throughout by branching assimilative hyphae  $4$  to  $8\mu$  wide. Conidiophores erect, colorless, meagerly septate,  $75$  to  $175\mu$  tall,  $3$  to  $4.5\mu$  wide at the base, about  $2.5\mu$  wide farther upward, often somewhat inflated at the top from which are given off  $3$  to  $8$  simple or branched sterigmata,  $2$  to  $7\mu$  long, whereon are borne collectively  $3$  to  $10$  conidia in loose capitate arrangement; additional conidial clusters often being produced following renewed axial elongation. Conidia colorless, cylindrical or somewhat clavate,  $15$  to  $28\mu$  long,  $4.5$  to  $5.5\mu$  wide, broadly rounded at the tip, often minutely pedicellate below, uniseptate, the  $2$  cells not pronouncedly unequal as a rule even though the lower cell is often slightly longer than the upper one.

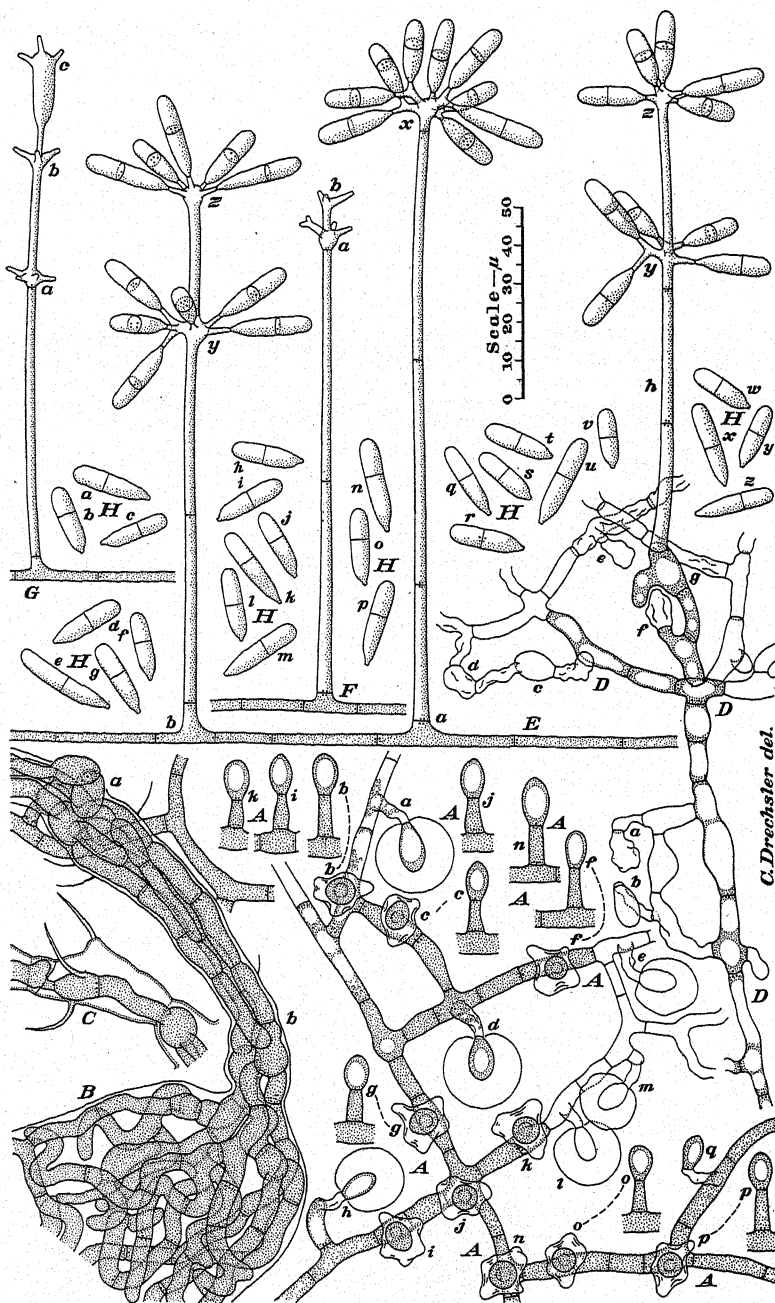
Capturing and consuming minute springtails referable to a species of *Sminthurides* very similar to *S. (Sphaeridia) serratus*, and occasionally also destroying various nematodes including *Plectus parvus*, it occurs in decaying roots of *Polygonum pennsylvanicum* in Arlington, Va.

The specific epithet in the new binomial is not intended to con-

FIG. 5. *Arthrobotrys entomopaga*.

vey the impression that *Arthrobotrys entomopaga* is considered to be probably the only fungus subsisting by capture of insects. On the contrary the close resemblance of the new species to familiar nematode-capturing forms gives reason to suspect that similar biotic adaptation may perhaps be uncovered in some of the various hyphomycetes which despite striking similarity and intimate relationship to species habitually preying on nematodes have under experimental conditions puzzlingly failed to capture eelworms or to form organs suitable for laying hold on minute animals of any kind (2: p. 538-540; 4: p. 349-360). In agar plate cultures planted with diseased rootlets or with leaf mold, these perplexing hyphomycetes ordinarily begin growing out of the vegetable detritus in much the same way as nematode-capturing forms, but, unlike the latter they cease developing after putting forth a scant display of conidiophores and conidia. Such discontinuance of growth might not unreasonably be expected in a predaceous fungus that after being introduced into a culture with some captured animals but without an escort of actively motile living prey, would need to conclude its production of mycelial hyphae and conidiophores as soon as the nutrient in the dead captives was exhausted. The different behavior of nematodes and springtails when material harboring them is used in planting agar cultures—the former little heeding the disturbance, the latter briskly springing away—would, from the start, tend to give the fungi predaceous on the two types of animals very unequal opportunity for visible extension into the transparent substratum. Later on, the slower hatching of springtail eggs as compared with nematode eggs, and the frequent failure of springtails to multiply well in agar cultures, must naturally operate to the further disadvantage of fungi subsisting on them. If adaptation for capture of insects may thus, perhaps, account in part for the meager development and unaggressive behavior of several fungi repeatedly tried out in the presence of nematodes and protozoans, it may, perhaps, likewise account for the fact that of the long-established hyphomycetous species manifestly belonging in the predaceous series only a small number have been recognized among the forms found preying on nematodes and protozoans.

At all events, the more minute of the terrestrial springtails ap-

FIG. 6. *Arthrobotrys entomopaga*.

pear well suited for extensive predaceous attack by mucedinous fungi. In their thoroughgoing infestation of decaying porous materials they roam the minute interstices and deeply ramifying passageways along which predaceous hyphomycetes can put forth adhesive organs under circumstances affording some protection against desiccation. The low position of their bodies relative to the floor on which they walk must facilitate ample contact with adhesive organs encountered by them. Their legs, though adequate for unobstructed walking, do not seem strong enough to overcome stubborn adhesion, nor are they attached in a manner favorable for effective traction. Once a minute springtail is securely held, its very thin integument could hardly be expected to offer much more resistance to hyphal penetration than is offered by the integument of a nematode.

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#### EXPLANATION OF FIGURES

FIG. 1. Predaceous mycelium of *Arthrobotrys entomopaga* with 4 captured springtails, *a-d*; one of the insects, *a*, seems little changed externally, having evidently been captured later than the 3 others, *b-d*, which not only look badly shrunk and collapsed, but offer a tousled appearance, owing to the several long aerial hyphae that extend for some distance above the substratum; the aerial hypha directed downward from insect *c* has given rise to the group of predaceous organs to the left of insect *d*. Unretouched photomicrographs taken with the microscope focussed on the surface of the substratum, and therefore showing the numerous adhesive bodies somewhat less distinctly than the underlying hyphal network; approximately  $\times 100$ .



FIG. 2. Predaceous mycelium of *Arthrobotrys entomopaga* with 6 captured springtails, *a-f*; 3 of the insects, *a-c*, seem little changed externally, having manifestly been captured later than the other 3, which appear badly collapsed. Unretouched photomicrographs taken with the microscope focussed about  $15\mu$  above the agar substratum, and therefore showing the numerous adhesive bodies more clearly than the underlying hyphal network; approximately  $\times 100$ .

FIG. 3. Predaceous mycelium of *Arthrobotrys entomopaga* with 6 captured springtails, *a-f*; 3 of the insects, *a-c*, seem little changed externally, having apparently been captured later than the other 3 noticeably collapsed ones, *d-f*. Unretouched photomicrograph taken with the microscope focussed about  $20\mu$  above the surface of the substratum, so that the adhesive bodies are shown more clearly than the underlying hyphal network; approximately  $\times 100$ .

FIG. 4. Predaceous mycelium of *Arthrobotrys entomopaga* with 7 captured springtails, *a-g*, in a somewhat collapsed condition; further, the disorganized remnants of 2 other captives, *h* and *i*, are faintly discernible within the same area. Unretouched photomicrograph taken with the microscope focussed on the surface of the substratum, and therefore showing the adhesive bodies less clearly than the underlying hyphal network; approximately  $\times 100$ .

FIG. 5. *Arthrobotrys entomopaga* as found developing in Petri plate cultures infested with springtails; drawn to a uniform magnification with the aid of a camera lucida;  $\times 500$  throughout. *A*, Hyphal network with many predaceous organs, some of them, *a-m*, newly formed under good protection against evaporation, showing each distal cell surrounded by a glistening droplet of adhesive liquid; *n*, a prostrate predaceous organ whose adhesive envelope is flattened out on the moist substratum, and from whose stalk has been sent up a new predaceous organ, *o*; *p*, a prostrate predaceous organ from the stalk of which a new predaceous organ, *q*, is growing out; *r*, a prostrate predaceous organ that from its base has given rise to one new predaceous organ, *s*, and from its distal cell has given rise to another predaceous organ, *t*; *u*, a prostrate predaceous organ whose terminal cell has given rise to the new predaceous organ, *v*, and besides has anastomosed with its parent hypha; *w*, a prostrate predaceous organ whose terminal cell has put forth 2 new predaceous organs, *x* and *y*, whereof one, *y*, on coming into a prostrate position has given rise to another predaceous organ, *z*. *B*, Portion of hyphal network bearing 6 predaceous organs, *a-f*, shown as seen when viewed from above, in their normal erect posture, and also shown lengthwise (without adhesive secretion) as seen when viewed after being pressed down strongly under a cover-glass. *C*, Portion of hyphal network with 7 predaceous organs, *a-g*, shown not only as seen from above in their normal erect posture, but also shown lengthwise (without adhesive secretion) as seen when pressed down strongly under a cover-glass. *D*, Portion of nematode, *Plectus parvus*, occupied by mycelium of the fungus; from this mycelium branches have been pushed through the integument to give rise externally to 8 predaceous organs, *a-h*, which have not yet secreted any adhesive material.

FIG. 6. *Arthrobotrys entomopaga*, as found developing in Petri plate cultures infested with springtails; drawn to a uniform magnification with the

aid of a camera lucida;  $\times 500$  throughout. *A*, Portion of hyphal network bearing 17 predaceous organs, *a-q*, among which seven—*a*, *d*, *e*, *h*, *l*, *m*, *q*—are in prostrate positions, with their envelopes of adhesive material flattened out on the substratum; the other organs, younger and still functional, being shown not only as seen when viewed from above in their normal erect posture, but also shown lengthwise (without adhesive secretion) as seen when pressed down strongly under a cover-glass. *B*, Portion of captured female springtail, showing part of its head and the two proximal segments of one antenna occupied by assimilative mycelium; *a*, region near articulation between second and third segments, where adhesive cell of a predaceous organ effected penetration of the antenna to initiate invasion of animal; *b*, articulation between first and second segments of antenna. *C*, Single assimilative filament in two proximal segments of an antenna of a male springtail. *D*, An old hyphal network with 6 empty collapsed adhesive cells, *a-f*, and a seventh adhesive cell, *g*, which, after coming into a prostrate position, has given rise to a conidiophore, *h*, bearing 2 conidial clusters, each containing 5 conidia. *E*, Portion of prostrate hypha from which have been sent up 2 conidiophores, *a* and *b*; the former bearing 9 conidia in a single cluster, *x*, the latter bearing 2 conidial clusters, *y* and *z*, containing 6 conidia and 5 conidia, respectively. *F*, Portion of prostrate hypha with a denuded conidiophore bearing 2 whorls of sterigmata, *a* and *b*. *G*, Portion of prostrate hypha with a denuded conidiophore bearing 3 whorls of sterigmata, *a-c*. *H*, Random assortment of conidia, *a-z*, showing variations in shape, size, and position of cross-wall.

## NOTES ON THE USTILAGINALES OF THE THE WORLD IV <sup>1, 2</sup>

GEORGE L. ZUNDEL

This paper reports proposed new species of smuts from various parts of the world and also new records of species already described. They all represent miscellaneous specimens sent to the writer during the compilation of a manuscript on the smuts of the world.

### **Ustilago Amphilophidis** Zundel, sp. nov.

Sori destroying the ovaries, inconspicuous, less than 2 mm. long, concealed by the glumes, spore-mass dark brown, semi-powdery; spores globose to subglobose, sometimes angular, tinted olivaceous-brown, chiefly 8-10.5  $\mu$  diameter, smooth.

Soris ovaria perdentibus, inconspicuis, minus 2 mm. longis, glumis tegentibus, massa sporarum atro-brunnea, semi-pulverulenta; sporis globosis vel subglobosis, interdum angularibus, olivaceo-brunneis, plerumque 8-10.5  $\mu$  diam., levibus.

On *Amphilophis ischaemum* Nash, Pathankot, Gurdaspur Dist., India. Collected by R. R. Stewart, May 11, 1917. Gordon College Herbarium, Plants of the Punjab No. 1776. Elev. 1000 ft.

### USTILAGO BURKILLII H. & P. Sydow.

On *Ancilema malabaricum* (L.) Merr., Tuguegarao, Cagayan Prov., Luzon, P. I. Coll. Dec. 29, 1923. Coll. Clemens No. 1741; Angat, Bulacan Prov., P. I. Coll. Clemens, Nov. 1924.

This species was abundant at Angeles, Pampanga Prov., Oct. 1923, Clemens.

<sup>1</sup> The willing coöperation of Dr. Robert E. Dengler, Professor of Classical Languages, The Pennsylvania State College, who wrote the Latin descriptions, is hereby gratefully acknowledged. Any errors are to be charged to the oversight of the author.

<sup>2</sup> Contribution from the Department of Botany, The Pennsylvania State College, No. 142, State College, Centre Co., Pa.

**USTILAGO CYNODONTIS** P. Henn.

On *Cynodon dactylon* (L.) Pers., Kigoma, Tanganyika Territory. Coll. Jan. 24, 1927. D. H. Linder, Flora of Tropical Africa No. 1953; coll. R. Thaxter, Oct. 1, 1905, Buenos Aires, Argentina.

**USTILAGO ISACHNES** Syd.

On *Isachne millacea* Roth., Sta. Maria, Bulacan Prov., Luzon, Nov. 1924. Coll. Clemens.

This is also abundant near Manila.

**TRANZSCHELIELLA OTOPHORA** Lavrov.

On *Stipa Lagascae* Roem. & Schult., Dayet Ahoua (Moyen-Atlas), Aug. 13, 1936. Champignons du Maroc 733 Ex. Herb. Crypt. G. Malencon.

**Ustilago jehudana** Zundel, sp. nov.

Sori destroying the anthers, spore-mass powdery, dark brown; spores globose to subglobose, regular, dark orange-brown, chiefly 10.5 to 14  $\mu$  diameter, reticulate.

Soris antheras perdentibus, massa sporarum pulverulenta, atro-brunnea; sporis globosis vel subglobosis, regularibus, atro-croceo-brunneis, plerumque 10.5-14  $\mu$  diam., reticulatis.

On *Silene apetala* Willd., Desert of Jehuda, Palestine. Coll. Dr. T. Rayss, March 25, 1935. Flora Cryptogamica Palestinae, Universitas Hebraica Hierosolymitana.

**Ustilago belgiana** Zundel, sp. nov.

Sori in the inflorescence, destroying the major part of the panicle from the base upward, dark-brown, powdery; spores globose to broadly ellipsoidal, regular, dark reddish-brown, chiefly 10.5-14  $\mu$  in diameter, abundantly but inconspicuously echinulate.

Soris in inflorescentia, majorem partem paniculi sursum a base perdentibus, atro-brunneis, pulverulentis; sporis globosis vel late ellipsoideis, regularibus, atro-rubro-brunneis, plerumque 10.5-14  $\mu$  diam., abundanter sed obscure echinulatis.

On *Digitaria horizontalis* Willd. and *Digitaria* sp., Kinshasa, Belgian Congo. Coll. D. H. Linder, Dec. 16, 1926, Flora of Tropical Africa (Expedition of the Harvard Institute of Tropical Biology and Medicine), No. 1614.

On *Digitaria Ischaemum* (Schreb.) Muhl., Sha Kan, Ch'ing Yang Hsien, Chiu Hua Shan, Prov. Ahnwei, China. Coll. S. Y. Chen, Oct. 24, 1932. Fungi of Ahnwei Province, China (Collected in coöperation between the Farlow Herbarium of Harvard University and the University of Nanking), No. 1394 and No. 1393.

***Ustilago lycoperdiformis* Zundel, sp. nov.**

Sori transforming the ovaries and stamens into brown, irregular globoid, swollen bodies 3–5 mm. diameter, with a powdery, violaceous spore-mass, spores discharged through an ostiole or slit on the upper part of the globoid bodies; spores globose to elongated, irregular, hyaline-violaceous, chiefly 5–8  $\mu$  in length, thickly and minutely echinulate under high magnification.

Soris ovaria atque stamina in corpora brunnea, irregularia, globose tumefacta mutantibus, 3–5 mm. diam., massa sporarum pulverulenta, violacea, sporis per ostiolum vel rimam ex superiore parte corporum globosorum emissis; sporis globosis vel elongatis, irregularibus, hyalino-violaceis, plerumque 5–8  $\mu$  longis, dense et minute echinulatis sub olei immersione, ut dicunt, visis. Hujus speciei sori maxime notandi sunt quippe qui Lycoperda perparva in massis referant.

On *Polygonum* sp., Loh Hoh Tsuen, Ling Yuin Hsien, China. Coll. by S. Y. Chen, April 1, 1933. Fungi of Kwangsi province, China (Collected in coöperation between the Farlow Herbarium of Harvard University and the University of Nanking), No. 1774.

The swollen sori of this species are very characteristic. *En masse* they resemble groups of miniature puff-balls.

***Ustilago morobiana* Zundel, sp. nov.**

Sori formed around the stem immediately below the floral parts, suppressing the development of the inflorescence, at first covered by a delicate membrane which flakes away revealing a dark, powdery spore-mass, entirely hidden by the enveloping leaf sheaths; spores globose to subglobose, occasionally cupped, reddish-brown, chiefly 3.5 to 6  $\mu$  diameter, smooth.

Soris circum caulem protinus sub partes florales consistentibus et inflorescentiae incrementum inhibentibus, membrana delicata in squamas dissipata atram pulverulentamque massam sporarum detegit, quam folia prorsus celant; sporis globosis vel subglobosis, interdum poculi formam praebentibus, rubro-brunneis, plerumque 3.5–6  $\mu$  diam., levibus. Haec species proxima est *Ustilagini Kusanoi* Syd. quam gigni in specie quadam *Miscanthi japonensis* referunt, sed differt eo quod tum soros dissimiles cum aliquantum majores et atriores sporas habet.

On *Miscanthus* sp., grassy hill, Boana, Morobe, New Guinea. Coll. M. S. Clemens, July 25, 1940.

This species is a very close relative to *Ustilago Kusanoi* Syd. described from Japan on *Miscanthus* species, but differs in having a different type of sorus, slightly larger and darker colored spores.

***Ustilago Stewartii* Zundel, sp. nov.**

Sori destroying the interior of the seeds, covered by the outer seed coat; spore-mass powdery dark-brown; spores globose to ovoid, chiefly regular, reddish-brown, chiefly 7-9  $\mu$  diameter, reticulate and coarsely winged.

Soris interiora seminum perdentibus, externo tegumine permanente; massa sporarum pulverulenta, atro-brunnea; sporis globosis vel ovoideis, plerumque regularibus, rubro-brunneis, plerumque 7-9  $\mu$  diam., reticulatis et crasse alatis.

On *Rheum Webbianum* Royle, Usi Mar, Deosai Plains, India. Coll. R. R. Stewart, Aug. 1, 1940. Plants of Kashmir, North-west Himalaya, elevation about 14,000 ft.

**FARYSIA CARICIS-FILICINAE S. Ito.**

On *Carex cruciata* Wahl., Loh Hoh Tsuen, Ling Yui Hsien, Kwangsi Province, China. Coll. S. Y. Cheo, March 28, 1933. Fungi of Kwangsi Province, China, No. 1742.

**FARYSIA MERRILLI (P. Henn.) Syd.**

On *Carex Rafflesiana* Boot., Mt. Santo Tomas, Benguet, Luzon. Coll. Clemens, March 26, 1935. Flora of the Philippines No. 15810.

**FARYSIA OLIVACEA (DC.) Syd.**

On *Carex Rafflesiana* Boot. var. *scaberrima* (Boeck.) Kukenth., Mt. Santo Tomas, Benguet Prov., Luzon, P. I. Coll. Clemens, Feb. 19, 1925. Very common.

***Farysia ugandana* Zundel, sp. nov.**

Sori destroying scattered ovaries throughout the panicle, ovoid, 4-8 mm. diameter, powdery, fine elaters intermixed with the spore-mass; spores globose to subglobose, slightly irregular, rarely elongate, olivaceous-brown, chiefly 3.5 to 7  $\mu$  in diameter, coarsely verruculate.

Soris ovaria per paniculum dispersa perdentibus, ovoideis, 4-8  $\mu$  diam., pulverulentis, elateribus tenuibus per massam sporarum intermixtis; sporis

globosis vel subglobosis, parum irregularibus, raro elongatis, olivaceo-brunneis, plerumque  $3.5-7\ \mu$  diam., crasse verruculatis.

On *Carex paniculata-spicata* B. B. Clarke, between Kinanira and Kisola, Uganda. Coll. D. H. Linder, April 3, 1927. Flora of Tropical Africa (Expedition of the Harvard Institute of Tropical Biology and Medicine), unnumbered.

*SPHACELOTHECA BOREALIS* (Clint.) Schell.

On *Polygonum* sp., Harbin, Manchuria. Coll. P. H. Dorsett, June 17, 1925, No. 3319.

*Sphacelotheca borealis* (Clinton) Schell. var. *chinensis* Zundel, var. nov.

This variety differs from the species in having the spores more regular and with more numerous sterile cells which are globose to subglobose, often irregular or angled,  $7-14\ \mu$  diameter.

Haec varietas a specie differt eo quod sporas magis regulares et plures cellas steriles habet. Hae cellae globosae vel subglobosae, saepe irregulares vel angulatae,  $7-14\ \mu$  diam., reperiuntur.

On *Polygonum Hydropiper* L., T'ien T'ai Wan, Ch'ing Yang Hsien, Chiu Hua Shan, Anhwei Province, China. Coll. S. Y. Cheo, Oct. 19, 1932. Fungi of Anhwei Province, China, No. 1314 (Collected in coöperation between the Farlow Herbarium of Harvard University and the University of Nanking).

*Sphacelotheca Caricis-Petitianae* Zundel, sp. nov.

Sori in the ovaries, destroying them, enlarged, globoid, about 3 mm. long, covered with a thin brownish membrane enclosing an olivaceous-brown, powdery, spore-mass surrounding a simple columella; sterile cells abundant, either singly or in long chains, hyaline, consisting of two sizes, oblong about  $3.5\ \mu$  wide or globoid to elongate, chiefly  $7-14\ \mu$  in length; spores very irregular in size and shape, globose to elongated or elongated and somewhat curved, often angular, olivaceous-brown, abundantly echinulate.

Soris ovaria perdentibus, dilatatis, globoideis, ca. 3 mm. longis, membrana tenui et brunnea, massa sporarum olivaceo-brunnea, pulverulenta, simplicem columellam circumstante; cellis sterilibus abundantibus, singulis vel longe catenatis, hyalinis, duarum magnitudinum—aut oblongatis ca.  $3.5\ \mu$  latis, aut globoideis vel oblongatis  $7-14\ \mu$  longis; sporis perirregularibus et forma et magnitudine, globosis vel elongatis vel subcurvatis, saepe angularibus, olivaceo-brunneis, abundanter echinulatis. Quantum scimus, ex scriptis quae

in promptu sunt, credimus hanc esse primam sphacelothecam in carice repertam.

On *Carex Petitiana* A. Rich., Belgian Congo. Coll. by Dr. Bequaert. Flora of Tropical Africa (expedition of the Harvard Institute of Tropical Biology and Medicine), unnumbered, 1926-1927.

Apparently this is the first *Sphacelotheca* ever reported on a *Carex* according to available records.

*SPHACELOTHECA CRUENTA* (Kuhn) Potter.

On *Sorghum vulgare* Pers. (*Andropogon Sorghum* Brot.), Chenkung, Yunnan, China. Coll. K. T. King, Oct. 1939.

*Sphacelotheca Linderii* Zundel, sp. nov.

Sori destroying the ovaries, globoid, about 2 mm. long, covered by a delicate membrane which flakes away revealing a dark-brown, semi-agglutinated spore-mass surrounding a well developed, simple, columella; sterile cells hyaline, about the same size and shape as the spores, often in groups; spores globose to subglobose, often irregular and angled, light reddish-brown, chiefly  $4-7\ \mu$  in diameter, abundantly but indistinctly echinulate under high magnification.

Soris ovaria perdentibus, globosis, ca. 2 mm. longis, membrana delicata in squamas dissipata massam atro-brunneam, semi-agglutinatum sporarum detegit quae columellam bene maturatam simplicemque circumstant; cellis sterilibus hyalinis, ejusdem fere magnitudinis formaeque ac sporae, saepe aggregatis; sporis globosis vel subglobosis, saepe irregularibus angulatisque, sub-rubro-brunneis, plerumque  $4-7\ \mu$  diam., abundanter sed obscure echinulatis etiam sub olei ut dicunt immersione visis.

On *Digitaria horizontalis* Willd., Belgian Congo. Coll. D. H. Linder, Dec. 2, 1936. Flora of Tropical Africa (Expedition of the Harvard Institute of Tropical Biology and Medicine), No. 1611.

*Sphacelotheca mauritiana* Zundel, sp. nov.

Sori destroying the stamens causing them to swell and twist, long linear, 0.5-1 cm. long, covered by a tough blackish-brown membrane which flakes away into sterile cells exposing a powdery spore-mass surrounding a brittle columella; sterile cells of two sizes, one globose,  $3.5-5\ \mu$  in diameter, hyaline, single; the other globose to irregular, up to  $10.5\ \mu$  in diameter, hyaline, singly, in pairs or in groups; spores globose to subglobose, somewhat irregular, bright olivaceous-brown, chiefly  $5-7\ \mu$  in diameter, echinulate under oil immersion.



Soris stamina tumefacientibus et torquentibus, mox perdentibus, longis linearibusque, 0.5–1 cm. longis, dura et atro-brunnea membrana, quae in squamas cellarum sterilium dissipata pulverulentam massam sporarum detegit, fragili columella; cellis sterilibus duarum magnitudinum—aliis globosis 3.5–5  $\mu$  diam. hyalinis singularibus, aliis globosis vel irregularibus usque ad 10.5  $\mu$  diam. hyalinis singulis vel binis vel congregatis; sporis globosis vel subglobosis, aliquantum irregularibus, clare olivaceo-brunneis, plerumque 5.7  $\mu$  diam. echinulatis sub olei ut dicunt immersione visis.

On *Stenotaphrum secundatum* (Walt.) Kuntze, near Reduit, Mauritius (Dept of Agriculture, Div. Plant Pathology, Mauritius). Coll. E. F. S. Shepherd, about 1941.

***Sphacelotheca nankingensis* Zundel, sp. nov.**

Sori destroying the flowers, filling them with a dark purple sport-mass surrounding a simple columella; sterile cells globose to subglobose, hyaline, chiefly 7–9  $\mu$  diameter; spores globose to subglobose or rarely elongated, violaceous, chiefly 10.5 to 12  $\mu$  diameter, finely echinulate under high magnification, thin epispore.

Soris flores perdentibus, massa sporarum atro-purpurea simplicem columellam circumstante; cellulis sterilibus globosis vel subglobosis, hyalinis, plerumque 7–9  $\mu$  diam.; sporis globosis vel subglobosis vel infrequenter elongatis, violaceis, plerumque 10.5–12  $\mu$  diam.; minute echinulatis sub olei, ut dicunt, immersione visis; epispore tenui. Haec species proxima *Sphacelothecae Polygoni-serrulati* Maire, sed differt eo quod crassum episporum non habet et quod sporae parum minores sunt.

On *Polygonum chinense* L., Shiang Lu Shih, Ch'ing Yang Hsien, Chiu Hua Shan, Anhwei Province, China. Coll. S. Y. Chen, Nov. 20, 1932. Fungi of Anhwei Province, China, No. 1327 (Collected in coöperation between the Farlow Herbarium of Harvard University and the University of Nanking).

This species is nearest *Sphacelotheca Polygoni-serrulati* Maire but differs in not having a thick epispore and having slightly smaller spores.

**SPHACELOTHECA PENNISETI-JAPONICI (P. Henn.) S. Ito.**

On *Pennisetum alopecuroides* (L.) Spreng, T'ien T'ai Wan, Ch'ing Yang Hsien, Chiu Hua Shan, Anhwei Province, China. Coll. S. Y. Cheo, Oct. 14, 1932. Fungi of Anhwei Province, China, No. 1245.

**SPHACELOTHECA TONGLINENSIS (Tracy & Earle) Zundel.**

On *Ischaemum ciliare* Retz., Bogar, Java. Coll. M. Raciborski, 1899. Det. W. Siemaszko. Ex-herb. W. Siemaszko.

Reported as *Sphacelotheca Raciborskii* sp. nov. in herb.

**Sphacelotheca tropico-africana** Zundel, sp. nov.

Sori destroying the inflorescence, globoid, about 5 mm. long, covered by a membrane which flakes away into sterile cells, revealing a dark purplish, semi-powdery spore-mass surrounding a well developed columella; sterile cells very numerous, resembling immature spores, thick walled, globose to subglobose, hyaline, 7-17  $\mu$  diameter; spores globose to subglobose or broadly ellipsoidal, regular, light violaceous, chiefly 10.5 to 14  $\mu$  diameter, granular, smooth, epispore thick, about 1.5  $\mu$  wide.

Soris inflorescentiam perdentibus, globosis, ca. 5 mm. longis, membrana dissipata in cellas steriles, massa sporarum atro-purpurea, semi-pulverulenta et satis grandem columellam circumstante; cellis sterilibus numerosissimis, formam sporarum immaturarum praebentibus, dense vallatis, globosis vel subglobosis, hyalinis, 7-17  $\mu$  diam.; sporis globosis vel subglobosis vel late ellipsoideis, regularibus, sub-violaceis, plerumque 10.5-14  $\mu$  diam.; granularibus, levibus, epispore crasso, ca. 1.5  $\mu$  lato.

On *Polygonum* sp., Kibati at the foot of Mount Ninagongo, Belgian Congo. Coll. D. H. Linder, Feb. 16, 1927. Flora of Tropical Africa (Expedition of the Harvard Institute of Tropical Biology and Medicine) No. 2182.

**CINTRACTIA PERIBEBUYENSIS** (Speg.) Sawada.

Syn. *Cintractia minor* (Clint.) H. S. Jackson.

On *Cyperus malaccensis* Lam., Aparri, Cagayan, Luzon Island, P. I. Coll. Clemens, No. 1752.

**SOROSPORIUM ARUNDINELLAE** Sydow.

On *Arundinella nepalensis*, Gilgandra, N.S.W., Australia. Collected 1928. No. 7.

**Sorosporium glutinosum** Zundel, sp. nov.

Sori destroying the inflorescence, at first enclosed by the sheath with only the upper part protruding, 4-9 cm. long, 0.5-1 mm. wide, covered by a yellowish membrane which flakes away exposing long shreds intermixed with the granular dark-brown spore-mass; spore-balls reddish brown, globose to subglobose, often irregular to angled, composed of 9 to 25 spores held together by a gelatinous fungus substance surrounding each spore, 42-73.5  $\mu$  long; spores subglobose to broadly ellipsoidal, somewhat irregular, dark reddish-brown, chiefly 14-17.5  $\mu$  in diameter, finely echinulate only on exposed surfaces, otherwise smooth.

Soris inflorescentiam perdentibus, vagina conditis et superiorem partem prominentibus, 4-9 cm. longis, 0.5-1 mm. latis, membrana flava, quae fracta

longas fibras cum granulati atque atro-brunnea massa sporarum commixtas detegit; massa sporarum rubro-brunnea, globosa vel subglobosa, saepe irregulari et angulata, sporas habente 9-25 singulas per materiam quandam fungosam et gelatinosam conglutinatas 42-73.5  $\mu$  longas; sporis subglobosis vel late ellipsoideis, aliquantum irregularibus, fusce rubro-brunneis, praecipue 14-17.5  $\mu$  diam., minute echinulatis in superficie exposita, aliter levibus.

On *Heteropogon contortus* (L.) Beauv., near Reduit, Mauritius (Dept. of Agriculture, Div. Plant Pathology, Mauritius, Exsicc. D/208).

SOROSPORIUM POLLINAE P. Magnus.

On *Andropogon distachys* L. (*Pollinia distachys* Spreng), Ki'u'at, Palestine. Coll. by Dr. T. Rayss, April 20, 1938. Flora Cryptogamica Palaestinae, Universitas Hebraica Hierosolymitana.

This seems to be the first report of this species since the original by Magnus.

SOROSPORIUM REILIANUM (Kuhn) McAlp.

On *Sorghum vulgare* Pers., Sze Nan Hsien, Kweichow Province, China. Coll. by S. T. Cheo, Oct. 27, 1931. Fungi of Kweichow Province, China, No. 340.

*Sorosporium tanganyikeanum* Zundel, sp. nov.

Sori destroying the inflorescence, partially concealed by the leaf sheath, long linear, 4-4.5 cm. long, covered by a yellowish membrane which flakes away revealing a powdery spore-mass with numerous fine, yellowish shreds intermixed with the spores; spore-balls ovoid to broadly ellipsoidal, many spored, opaque, dark brown, semi-permanent, chiefly 52 to 87.5  $\mu$  long; spores globose to subglobose, frequently irregular, light olivaceous-brown, chiefly 5-7  $\mu$  diameter, smooth.

Soris inflorescentiam perdentibus, in vagina folii partim celatis, longis, linearibus, 4-4.5 cm. longis, membrana subflava in squamas dissipata massam pulverulentam sporarum ostendit, frustis tenuibus et subflavis cum sporis copiose commixtis; globis sporarum ovoideis vel late ellipsoideis, sporis numerosis, opacis, atro-brunneis, semi-perpetuis, plerumque 52-87.5  $\mu$  longis; sporis globosis vel subglobosis, saepe irregularibus, clare olivaceo-brunneis, 5-7  $\mu$  diam., levibus.

On *Panicum repens* L., Kigoma, Tanganyika Territory, Africa. Coll. D. H. Linder, January 24, 1927. Flora of Tropical Africa (Expedition of the Harvard Institute of Tropical Biology and Medicine), No. 1955.

**Sorosporium terrareginalense** Zundel, sp. nov.

Sori destroying the inflorescence, at first hidden by the glumes, long, cylindrical, about 1–1.5 cm. long, covered by a yellowish membrane which dehisces apically exposing a dark spore-mass, at first semi-agglutinated but later granular, powdery, intermixed with elators or shreds of host tissue, spore-balls dark, at first firm, later disintegrating, variable in shape and size, subglobose to angular, 50–110  $\mu$  in length; spores variable in shape, subglobose to elongated, chiefly angular, often irregular, dark olivaceous-brown, epispore concolorous, chiefly 10.5 to 17.5  $\mu$  in length, smooth.

Soris inflorescentiam perdentibus, primo celatis in glumis, longis cylindricis, ca. 1–1.5 cm. longis, flava membrana rupta et ad apicem dehiscens fuscam massam sporarum detegit, primo semi-agglutinatum, inde granularem pulverulentamque et elatoribus fibrisque hospitis intermixtam; massis sporarum fuscis firmisque, mox solutis varias formas magnitudinesque habentibus, subglobosis vel angularibus, 50–110  $\mu$  longis; sporis variformibus, subglobosis vel elongatis, praecipue angularibus, saepe irregularibus, fusce olivaceo-brunneis, epispore concolori, praecipue 10.5–17.5  $\mu$  longis, levibus.

On *Cymbopogon refractus* (R. Br.) A Camas, Highway near Mt. Coot-tha, Brisbane, Queensland, Australia. Coll. M. S. Clemens, Feb. 9, 1943. (No collection number.)

**Sorosporium texanum** Zundel, sp. nov.

Sori destroying the inflorescence, long linear, about 8 cm. or more long and 2 mm. wide, covered by a thick, pinkish-white membrane which shreds from the apex downward revealing a very hard compact, stuffed, dark-brown spore-mass which soon disintegrated into a granular mass; spore-balls ovate to elongate, many-spored, opaque, semi-permanent, 52.5–105  $\mu \times 45$ –70  $\mu$ ; spores subglobose, often irregular and sometimes angled, light olivaceous-brown, chiefly 7–10.5  $\mu$  diameter, smooth.

Soris inflorescentiam perdentibus, longis, linearibus, ca. 8 cm. vel amplius longis, 2 mm. latis, membrana crassa et subpunicco-alba ab apice minutatim dissecta perduram compactamque massam atro-brunneam sporarum detegente, massa speciem granorum mox praebente. Globis sporarum ovatis vel elongatis, multisporeis, opacis, semi-permanentibus, 52.5–105  $\mu \times 45$ –70  $\mu$ ; sporis subglobosis, saepe irregularibus et interdum angulatis, clare olivaceo-brunneis, plerumque 7–10.5  $\mu$  diam., levibus. Quia specimen vile tantummodo aderat, haec species profundius investiganda erit.

On *Pennisetum nervosum* (Nees) Trin., Fort Brown, Brownsville, Texas. Coll. Hansel, Dec. 23, 1942. No. 52794. Comm. J. A. Stevenson.

This species requires more careful study since only a very poor specimen was available for study.

*THECAPHORA HAUMANI* Speg.

On *Iresine celosia* L., San German, Puerto Rico. Coll. Ismael Velez, June 6, 1943. Comm. Carlos E. Chardon. Det. G. L. Zundel.

*MELANOPSICHIMUM AUSTRO-AMERICANUM* (Speg.) Beck.

On *Polygonum minus* Huds., Baguio, Luzon, P. I., elev. 4-5000', wet grassy place. March 14, 1935.

? *TILLETIA AYRESII* Berk. (poor spec.)

On *Panicum maximum* Jacq., Bumba, Belgian Congo. Flora of Tropical Africa, 1817a. Coll. D. H. Linder, Dec. 29, 1926.

*TILLETIA PENNISETINA* Syd.

On *Pennisetum alopecuroides* (L.) Spreng, Ch'ing Yang Hsien, Chiu Hua Shan, Anhwei Province, China. Coll. by S. Y. Cheo, October 15, 1932. Fungi of Anhwei Province, China, No. 1258.

On *Pennisetum compressum* R. Br. Coll. Oct. 10, 1925, by Yu Ta-fuh, waste land, Nanking, Kiangsu Province, China. Fungi of China, Herb. Univ. Nanking No. 741. Comm. R. H. Porter.

*Tilletia Rhei* Zundel, sp. nov.

Sori destroying the interior of the seeds, spore-mass agglutinated, semi-hard, somewhat intermixed with host tissue; spores globose to subglobose, chiefly regular, dark reddish-brown, chiefly 16-19  $\mu$  diameter, coarsely reticulate, coarsely winged around the edge of the spores; hyaline cells scattered throughout the spore-mass appearing as immature spores.

Soris interiora seminum perdentibus, massa sporarum agglutinata semidura, aliquantum cum materie hospitis intermixta; sporis globosis vel subglobosis, plerumque regularibus, atro-rubro-brunneis, plerumque 16-19  $\mu$  diam., crasse reticulatis, crasse alatis in margine sporarum; hyalinis cellis per massam sporarum velut sporis immaturis apparentibus.

In the seeds of *Rheum Franzenbachii* Muent. (*R. undulatum* L.; *R. rhubarbarum* L.), Shansi: Chiao-Ch'eng, distr. Yün-ting-Shan, ad rupes in pratis alpinis ca. 2500 m.s.m., China. Coll. Harry Smith, Sept. 2, 1924. Mus. Botan. Stockholm No. 7451. Host. det. G. Samuelson 1928.

***Urocystis Colchici-lutei* Zundel, sp. nov.**

Sori as small elongated, ovoid pustules on the stem, about 1 mm. long, spore-mass powdery, rusty colored; spore-balls of various sizes and shapes, chiefly 20–50  $\mu$  in diameter, composed of one to three or rarely four fertile spores which are usually completely surrounded by the sterile cells, bright reddish-brown, usually concolorous; sterile cells thick walled, almost the same color as the spores; spores globose to subglobose, bright reddish-brown, chiefly 10.5 to 14  $\mu$  diameter, smooth.

Soris elongatis et ovoideis velutque pustulis in stirpe locatis, ca. 1 mm. longis, massa sporarum pulverulenta, robiginosa; globis sporarum forma et magnitudine diversis, praecipue 20–50  $\mu$  diam., ex una vel tribus vel raro quattuor sporis fertilibus compositis atque intra densos parietes cellarum sterilium plerumque contentis, clare rubro-brunneis, ferme concoloribus; sporis globosis vel subglobosis, clare rubro-brunneis, plerumque 10.5–14  $\mu$  diam., levibus. Haec species ab *Urocystide Colchici* differt eo quod sorum minorem, globam sporarum clariorem, sporas globarum numerosiores habet.

On *Colchicum luteum* Baker, Abbottabad, India. Coll. R. R. Stewart, April 15–18, 1935. Gordon College Herbarium, Plants of Hazara N. W. F. P., Northwest Himalaya No. 14616, elev. about 4200 ft.

This species differs from *Urocystis Colchici* by the smaller sorus, brighter colored spore-balls and more spores per spore-ball.

**UROCYSTIS TRITICI Körn.**

On *Triticum* sp. cult., Cauquenes, Chile. Coll. Sr. Juan Mandakovic, det. Sr. Sigurd Arentsen. Comm. Dept. de Sanidad Vegetal. Ministerio de Agricultura, Santiago.

***Entyloma wyomingense* Zundel, sp. nov.**

Sori as small brownish-white irregular spots 0.5 mm. or less to 2 mm. in diameter, most distinct on the upper side; spores very abundant, globose to subglobose, chiefly regular, light reddish-brown, chiefly 14–17.5  $\mu$  in diameter, smooth, thick epispore about 2  $\mu$  wide.

Soris maculis parvis, brunneo-albis et irregularibus, 0.5 mm. vel minus ad 2 mm. diam., in superiore superficie magis distinctis; sporis maxime abundantibus, globosis vel subglobosis, praecipue regularibus, clare rubro-brunneis, praecipue 14–17.5  $\mu$  diam., levibus, episporo crasso ca. 2  $\mu$  lato.

On *Delphinium Barbeyi* Huth., Medicine Bow Mountains, Wyoming. Coll. Aven Nelson, Aug. 10, 1914. The Rocky Mountain Herbarium No. 9678.

**Doassansia Rhinanthi** Lagh. sp. nov. in litt.

Sori as small brown raised, globoid pustules on the stem, .25 to .5 mm. diameter, each containing one spore ball, often two or more pustules are fused; spore-balls dark brown, opaque, 300 to 350  $\mu$  diameter; outer cortical tissue consisting of a single layer of reddish-brown sterile cells, irregular, angular, chiefly 7-8  $\mu$  diameter; spores globose to subglobose, often irregular and angled, crowded, entirely filling the inner part of the spore-ball, hyaline, 10-12  $\mu$  diameter, smooth.

Sori parvis brunneis elevatis velut pustulis globosis in caule orientibus, .25-.5 mm. diam., globis sporarum singulis, frequenter duobus plusve pustulis fuis; globis atro-brunneis, opacis, 300-350  $\mu$  diam.; cortice externa ex singulis et sterilibus rubro-brunneisque cellis consistente, irregularibus, angularibus, plerumque 7-8  $\mu$  diam.; sporis globosis vel subglobosis, saepe irregularibus et angulatis, densis, interiorem partem sporarum globae prorsus replentibus, hyalinis, 10-12  $\mu$  diam., levibus. Hoc specimen in exsiccatis, quae apud herbarium Collegii Reipublicae Pennsylvaniensis continentur, repertum est. Videtur numquam ante descriptum esse, vel saltem in litteris quae in promptu sunt nusquam apparet. Quamvis deterius sit specimen, versa *Doassansia* videtur, quapropter hanc descriptionem interdum praebuimus, dum materies melior et ad studium curatius aptior adsit. Garcke, in Ill. Flora Germaniae. hospitem nominat *Fistulariam Cristam galli* (L.) Wettstein; at ei, qui apud nos Scrophulariaceas maxime tractant, nomen generis *Rhinanthum* esse ducunt.

On *Rhinanthus minor* Ehrh., Wilmersdorfer, Wessen, Berlin, Germany, leg. P. Sydow, Nov. 22, 1895 (Sydow, Myc., March, 4306).

The specimen of this smut was found while going through the exsiccati in the Pennsylvania State College herbarium. Apparently there has been no published description, or at least none has been found in available literature. While the material is poor, it seems to be a good *Doassansia* and therefore the above description is tentatively given until better material is available for more careful and detailed study. Garcke in his Ill. Flora von Deutschland lists the host as *Fistularia Crista galli* (L.) Wettstein, but specialists on the Scrophulariaceae report that the genus name *Rhinanthus* is the valid name.

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## APHANOMYCES AS A FISH PARASITE

LELAND SHANOR AND HERBERT B. SASLOW

(WITH 1 FIGURE)

During November, 1942, a serious outbreak of a fungal disease on fish developed in some of the aquaria in the Vivarium of the University of Illinois. The macroscopic appearance of the fungus on the infected fish suggested a water mold, possibly a delicate species of *Saprolegnia*, as the causal organism. Microscopical examination and cultural studies of the parasite revealed it to be a sterile *Aphanomyces*. Certain species of *Saprolegnia*, *Achlya*, and *Dictyuchus* are known to parasitize fish and in some instances to cause serious trouble. *Aphanomyces* species, however, are more widely known as plant parasites or as parasites of such Invertebrates as the European Crayfish and of some smaller fresh water *Crustacea*. Because of the severity of the epidemic here and its unusual occurrence as a parasite on fish,<sup>1</sup> we deem it of some interest to publish this brief account.

The first infection was noted in a small one gallon aquarium November 4th, 1942, and was observed in other aquaria within a few days. The fish in two small aquaria, those in a 28 gallon rectangular aquarium and those in a large concrete burial vault used as an aquarium, were almost entirely eliminated by this organism within a period of about two weeks. The source of inoculum is not known but it is probable that it was introduced along with some food materials grown in containers of fresh water kept outside of the Vivarium.

Adults as well as young were attacked in a characteristic manner and the virulence of the organism on both age groups was equally

<sup>1</sup> We have been unable to find any previous records of *Aphanomyces* occurring on fish. In this search of the literature we wish to acknowledge the help of Dr. D. H. Linder, who generously checked through the host index of the Farlow Reference Library for citations, and of Dr. W. N. Tiffney, who kindly looked through his personal file of references to fungal parasites of fish.



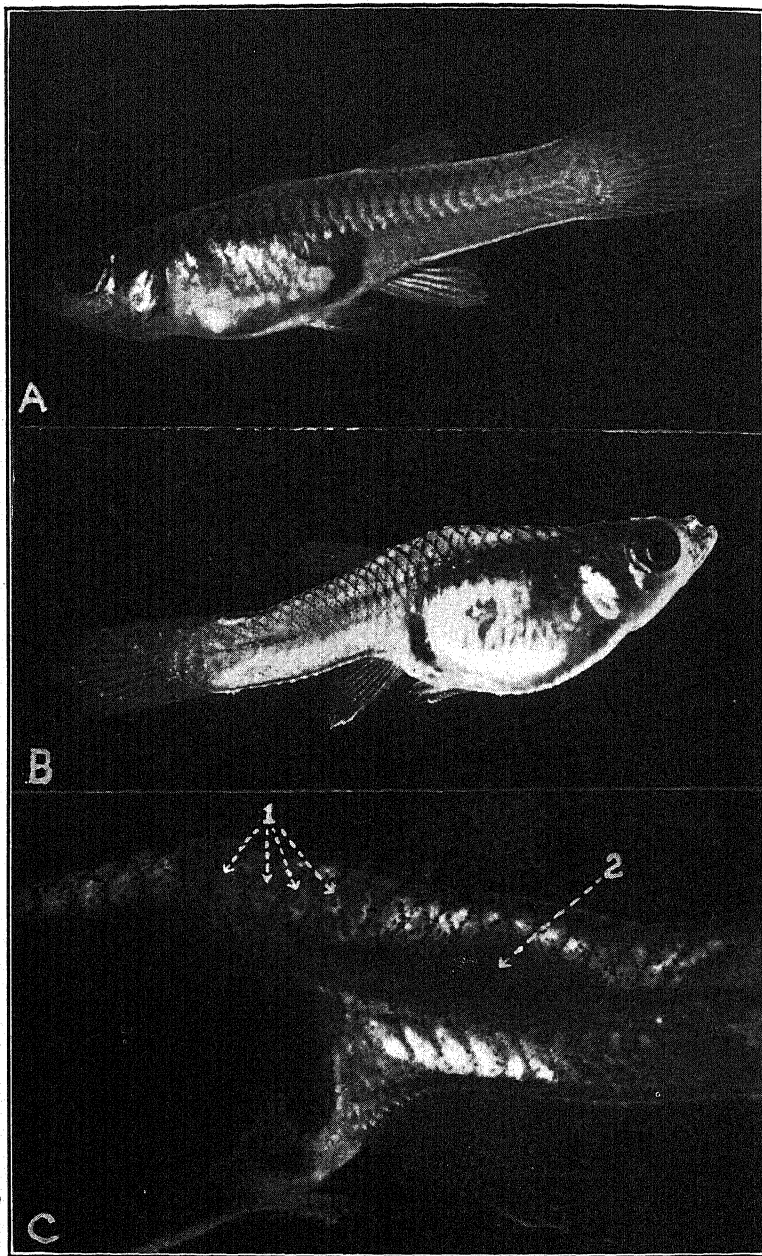


FIG. 1. *Lebistes reticulatus* Peters. *A*, normal young female; *B*, parasitized young female showing characteristic humped condition, an early symptom of the disease; *C*, central portion of the body enlarged to show mats of mycelium within dorsal musculature (1), and a lesion from which hyphae protrude (2). *A* and *B* about  $\times 4.3$ , *C* about  $\times 10.4$ . (Photographs by George Svihla.)

severe. The following fish were represented in the various infected aquaria: *Lebistes reticulatus* Peters (Guppy), *Anoptichthys jordani* Hubbs and Innes (Mexican Blind Cave Fish), and a hybrid of *Platyopocilus maculatus* Guenther (Platy)  $\times$  *Xiphophorus helleri* Heckel (Swordtail). All of these seemed about equally susceptible to infection by this species of *Aphanomyces*.

The method of infection is not known. Previously acquired injury lesions or other evidence of any unhealthy condition were not detected in any of the specimens. The first evidence of *Aphanomyces* infection to be observed was a peculiar abnormal dorsal hump (FIG. 1, B). The parasite usually developed most extensively in the dorsal region (FIG. 1, C) and its activity in the musculature here seemed to be responsible for this peculiar spinal curvature. A few days later, the mycelium of the parasite was evident as whitish lumps within the distended musculature (FIG. 1, C.1). Soon after this first appearance of macroscopic symptoms of a diseased condition, the hyphae began to protrude from the lumps in tufts which extended out from the skin for a length of about 2 mm. Isolations were made of the external hyphae from these areas as well as from portions of the infected tissue, but only *Aphanomyces* was recovered. The *Aphanomyces* seemed to be the parasite entirely responsible for the condition and not an organism which had entered after the host tissue had been injured or when the vitality of the host had been lowered by some other primary type of infection. Usually within a week after lesions developed parasitized fish succumbed. None of the fish that became infected have recovered.

We have been unable to identify the species of *Aphanomyces* observed and isolated for sexual reproductive structures have not developed in any of the cultures and none have been observed in the infected tissue or on hyphae extending from lesions. It grows quite well on a number of culture media such as maltose-peptone agar, hempseed, grubs, etc. It is obviously a facultative parasite which may become destructive under suitable conditions.

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## VOLUTELLA BUXI AND VERTICILLIUM BUXI

B. O. DODGE

The occurrence of a blight of dwarf English boxwood at East Hampton, L. I. was noted in a recent number of MYCOLOGIA (Dodge, 1944). Some of the blight was of the type usually referred to as wilt. Most of the leaves lost their chlorophyll and became thin or papery and very light straw-colored. Andrus (1933) and others have suggested that it may be a *Verticillium*, rather than winter killing, that brings on such a blight. One could see where in the East Hampton planting the owners had from time to time cut off other dead stems.

Both *Verticillium Buxi* and *Volutella Buxi* often developed when a branch bearing leaves infected with *Hyponectria Buxi* was placed in a damp chamber. It is a fact as stated by Dodge and Swift (1930), and easily verified, that cultures derived from conidia taken from sporodochia of *Volutella Buxi* in nature develop a *Verticillium* or *Acrostalagmus* phase preceding the formation of sporodochia. These authors did not realize, however, that the *Verticillium* that appeared in their cultures of *Volutella* might not be the true *Verticillium Buxi*. Further evidence is presented in this paper showing that *Volutella Buxi* and *Verticillium Buxi*, as Juel (1925) some years ago reported, are two very different species.

### VERTICILLIUM BUXI

As a rule the sporophores are snow-white and evenly scattered over the under sides of the leaves. The conidia germinate slowly on a potato dextrose agar medium and the mycelial growth is also very slow. The mycelial mat is rather tough. The first aerial growth is composed of whitish, erect branches. Later growth is zonate, some zones being light pink to rose or peach colored. Old plate cultures are of a deep-rose color.

Small potted boxwood plants, kindly furnished by Drs. John M. Arthur and P. W. Zimmerman of Boyce Thompson Institute, were sprayed with spore suspensions and kept under bell jars in the laboratory for some time. It was nearly two weeks before certain new leaves became infected. Later on a number of the old leaves also became covered on the under side with the snow-white *Verticillium*. One of the four plants inoculated showed *Volutella Buxi* on a few leaves at the tip of a twig that must have been infected previously in nature. The other three plants inoculated developed only the *Verticillium*.

Leafy branches of different varieties of boxwood were then placed in large Petri-dishes, well moistened and autoclaved. The leaves were inoculated with a spore suspension. Within a few days all the leaves showed a fine growth of *Verticillium* on the under side, but no *Volutella* ever developed.

The spores of this *Verticillium* are broadly spindle-shaped and rather pointed at the ends. As they are formed one after another they adhere along their sides, being held together in long white chains, presenting the appearance of a white *Penicillium*. The conidia are apparently not easily dislodged or blown away by wind. When the dry tufts of conidiophores are placed in a drop of water the conidia are quickly dispersed with a jittery motion. It is only when very moist conditions prevail and growth is luxuriant that the conidia mass together and become slightly roseate. On potato dextrose agar in old cultures the conidial masses are deeply roseate. In this condition the culture presents somewhat the appearance of sporodochia of *Volutella* or of *Gliocladium*. Our infection experiments with living plants prove that this *Verticillium* is certainly not ordinarily a primary leaf blight. It is difficult to infect living leaves even under the abnormal conditions that prevail under bell jars.

#### VOLUTELLA BUXI

The feature that distinguishes a *Volutella* from other related genera is the presence of hairs or setae around the margin of the sporodochium. In nature as well as in culture many sporodochia of *Volutella Buxi* are wholly devoid of setae. The sporodochia may arise beneath the epidermis bursting out as whitish mounds

or pads of fungous growth which later becomes beautifully colored roseate or coral. The sporodochia are often developed on short stalks composed of compacted mycelial growths which have emerged through stomatal openings. The setae are rather short, coarse and have blunt ends. They arise from the base of the fruiting structure and grow up around the margin. A characteristic mark is the ruby-red drops of sticky substance at the tips of the hairs. This substance hardens on drying and may persist in herbarium specimens. It is readily dissolved in water so that in nature as well as in herbarium specimens the hairs may not be marked by the red beads.

The conidia of *Volutella Buxi* germinate quickly on potato dextrose agar. The mycelium grows about five times as fast as does that of *Verticillium Buxi*. The hyphae are also coarser. While the first growth is whitish, it becomes light pink or dull peach colored as the culture ages. In plate culture the growth is somewhat dappled or spotted and the mat is not at all leathery. Within two or three days sporulation begins. The conidia, in their shape and size, are similar to those of *Verticillium Buxi* but are more rounded or elliptical, and vary exceedingly in size. At first they are developed one by one at the ends of fairly long side branches of ascending or prostrate aerial hyphae which grow radially out from the point of inoculation. The fertile hyphae may grow along singly for some time but they often twist together in a sort of rope. As conidia develop they are held in a drop of clear watery substance so that the picture is sometimes much like that of a *Cephalosporium*. Cooke (1871) evidently mistook this stage for a *Mucor* which he thought was the perfect stage of *Penicillium roseum*. This point will be discussed later. Within a very few days one sees sporophores with verticillate branches, the ends of which are capped by drops of clear liquid containing many conidia, suggesting now an *Acrostalagmus*.

The next stage includes the massing together of a number of conidiophores as figured by Dodge and Swift (1930). From here on sporodochia of various types develop. Some of these bear coarse setae several cells in length, with rather rounded or blunt tip ends, usually capped with reddish drops.

Living boxwood plants were sprayed with a suspension of co-

nidia and kept under bell jars. Within a week or so numerous leaves became infected. They were first covered on the under side with a white fluffy growth which later matted down on the leaf surface. Very soon large numbers of pink to coral colored sporodochia, with or without marginal hairs, were developed. None of the snow-white sporophores characteristic of *Verticillium Buxi* ever developed. Under moist conditions the sporodochia run together in a brightly colored sheet, showing few if any setae. Occasionally large sporodochia develop beneath the epidermis, then burst through as acervuli.

*Volutella Buxi* differs from *Verticillium Buxi* in several ways. In nature the conidia of the *Volutella* are pinkish roseate or coral color in mass. They are not as sharply pointed at the ends as are the conidia of the *Verticillium*. They also vary greatly in size. The sporophores of *Verticillium Buxi* are at first snow-white, seldom in nature acquiring a roseate or pinkish color. The conidia are broadly spindle-shaped, and adhere together by their sides in chains. On potato dextrose agar it is the *Verticillium* that develops the more beautiful roseate hues. Sterilized leaves of boxwood when inoculated with the *Volutella* develop the various forms which may include a *Cephalosporium* stage, a *Verticillium* or *Acrostalagmus* stage, and finally, a true sporodochial stage, with or without setae. When sterilized leaves are sprayed with a spore suspension of *Verticillium Buxi*, the under sides of the leaves become completely covered with a snow-white layer of verticillate sporophores. Under moist conditions, especially in old cultures, as noted previously, there is a massing of sporophores in the form of sporodochia which may be somewhat colored.

Heretofore many authors have assumed that the species variously identified as *Volutella Buxi* and *Verticillium Buxi* are merely two different types of fructification of one species. Others have taken the position that proof for such a connection has not been presented. After our culture work had proved clearly that there are two distinct species, a *Volutella* and a *Verticillium*, growing together, often on the same leaves of boxwood, a search of the literature on this point resulted in the finding of a paper by Juel (1925) which seems to have been overlooked by most of us. Juel did not use the single-spore culture method, but there can be no

question he was the first to prove that *Volutella Buxi* and *Verticillium Buxi* are two distinct species. Whether his conclusions as to their perfect or ascocarpic stages were well founded may be questioned. He agreed with previous authors that the perfect stage of the *Volutella* is *Nectriella Rousseliana* (Mont.) Sacc., because of the frequent association of these forms on the same leaves. He insisted, however, that there could be found in herbarium specimens as well as in nature, another, different and undescribed, species of *Nectriella* which he believed to be the perfect stage of *Verticillium Buxi*. He described this ascomycete as *Nectriella coronata* because of the corona of fine hairs which surround the ostiolar region. The writer has seen ascocarps of this type on leaves of herbarium specimens from Europe and also on one American specimen collected originally by Ravenel in South Carolina. Juel was unable to produce ascocarps of either species of *Nectriella* in his cultures on sterilized leaves or on prune agar. He did find in his cultures what he believed to be incipient ascocarps of the *Verticillium*. The writer has seen such structures on artificially infected leaves, but they did not develop far enough to prove anything. No such structures were seen on the sterilized leaves infected with the *Volutella*.

#### NECTRIELLA ROUSSELIANA VAR. VIRIDIS

Of great interest were some ascocarps which developed on twigs and leaves of boxwood from the East Hampton material. Both *Volutella Buxi* and *Verticillium Buxi* had developed on certain leaves and twigs in one damp chamber. Along with these structures there appeared some beautiful light chlorophyll-green fruiting bodies which were of about the size and shape of a *Nectriella*. As these bodies continued to enlarge they developed numbers of stiff hairs scattered over the surface. The perithecia were much like the one figured by Juel (1925) for *Nectriella Rousseliana*. The only difference was that on our specimens the hairs were always capped with bright ruby-red beads. These setae were like those found on sporodochia of *Volutella Buxi*, only they were more numerous in some cases, and thicker and stiffer. As the perithecia developed the chlorophyll-green color gradually deepened and finally changed to a black-green color, which later again changed

to amber brown. Practically all these ascocarps collapsed without ever showing any asci or spores which could be definitely determined as ascospores. Failure to develop asci may have been due to a chytrid (?) parasite which was present. This material showed that not all the ascocarps bore large numbers of stiff hairs. There were so many different stages in the development of the ascocarps represented that there could be no question that the beautiful green bodies mentioned were young perithecia, probably of *Nectriella Rousseliana*. Whether the ascocarps of this species are always green when young may be questioned.

The connection between this form and *Volutella Buxi* has not as yet been established by growing ascospores. The mere presence of the two forms, the *Volutella* and the *Nectriella* together on a leaf or twig, no matter how frequently, is, of course, no proof whatever of a connection. On the other hand the development of the same type of hairs on the sporodochia and on the perithecia, hairs that are in both cases ornamented with drops of ruby-red substance, certainly is better evidence of a connection. Both fruiting structures are haploid, having grown from haploid mycelia, in this case, both carrying the same genes for hair type. This would be but another example of similarities existing between the so-called sexual and asexual fruiting structures.

Berkeley and Broome (1859), under No. 898, described a new variety on boxwood leaves as *Nectria Rousseliana* var. *viridis*. "Peritheciis siccis atro-viridibus madidis prasiis ovalis pilis sparsis hyalinis obsitis; sporidiis ellipticis." They said that except as to the green color (leak colored when moist, blackish-green when dry) their plant resembled so closely that described by Montagne that they hesitated to make it a distinct species. No doubt what we at first thought was a discovery had, nearly a century previously, been made by Berkeley and Broome. They made no mention of the ruby colored beads on the ends of the hairs, however!

#### PENICILLIUM ROSEUM LINK AND PENICILLIUM ROSEUM COOKE

Just what fungus from stems of *Solanum tuberosum* Link had before him when he described *Penicillium roseum* cannot be known with certainty. We are here concerned more with those fungi



found on leaves of boxwood and variously identified or distributed as *Penicillium roseum*, *Volutella Buxi*, *Verticillium Buxi* and otherwise. Dr. Charles Thom has pointed out to the writer personally that in his work, "Penicillia," under *Gliocladium roseum* (Link?) Bainier he referred to No. 1179 *Penicillium roseum* De Thümen Myc. Univ. on leaves of boxwood. Ravenel's material was evidently widely distributed. Our packet of No. 1179 represents mostly *Volutella Buxi* although some *Verticillium Buxi* is present. Ravenel's No. 571, Fungi Am. Exs. *Penicillium roseum* Link, contains three leaves which bear only *Volutella Buxi*, one leaf only *Verticillium Buxi*, and four leaves both species. The writer is indebted to Dr. Kenneth Raper for two cultures of *Gliocladium* from the Thom collection. Neither No. 1084, *G. roseum* nor No. 1752, *G. vermoeseni*, is now like any of the species of fungi we have seen on boxwood.

No. 1794 Sydow, Myc. March. "*Penicillium roseum* Link" has both *Volutella Buxi* and *Verticillium Buxi*. A packet "Ex herb. de Thümen, *Penicillium roseum* Link" and bearing what is said to be Ellis' number 2883 is a beautiful collection of *Volutella Buxi* with five leaves showing numbers of ascocarps of *Nectriella Rous-seliana*, bristling with coarse hairs some of which are still capped by the ruby-red droplets. The sporodochia of the *Volutella* present even after 77 years show similar hairs also with the reddish droplets at the ends. Here also the ascocarps are strongly collapsed.

No. 828, Ellis, N. Am. Fungi, "*Penicillium roseum* Link," is mostly *Verticillium Buxi* with some of the *Volutella*. Ellis' No. 810, "*Volutella Buxi*," is a mixture of the *Volutella* and the *Verticillium*. No 2593, Ellis & Ev. N. Am. Fungi, *Verticillium Buxi*, is all *Volutella Buxi*. Several packets collected by F. W. Anderson at Washington and distributed as *Verticillium Buxi*, represent mostly *Volutella Buxi*. The "*Penicillium roseum* Link?" reported and figured by Swift (1929) is neither our *Volutella* nor our *Verticillium*.

The real *Verticillium Buxi* certainly looks like a white *Penicillium*. No doubt under certain conditions the conidial masses become roseate. If *Volutella Buxi* in its various sporophore types, some pinkish or roseate, is represented on the same leaf with the

*Verticillium*, confusion must always exist. We are probably safe in concluding that when *Penicillium roseum* has been reported on boxwood, either *Verticillium Buxi* or *Volutella Buxi* (or both) was present. The *Penicillium* idea comes from the *Verticillium*, and "roseum" idea is primarily due to the *Volutella*.

MUCOR HYALINUS COOKE, AND PENICILLIUM ROSEUM  
COOKE NOT LINK

Cooke (1871) under the title "Polymorphic fungi" writes as follows: "Some two or three years ago we collected a quantity of dead box-leaves on which grew a mould named by Link, *Penicillium roseum*. This mould has a roseate tint, and occurs in patches on the leaves; the threads are erect and branched above, bearing oblong, somewhat spindle-shaped, spores. When collected these leaves were examined and nothing was observed or noted upon them except *Penicillium*. After some time, incidently between two or three years, during which the [tin] box remained undisturbed, circumstances led to the examination again of one or two of the leaves, and afterwards a greater number of them, and patches of *Penicillium* were found to be intermixed with another mould of a higher development and of far different character (Pl. LXVIII. fig. 5). This mould, or rather *Mucor* for it belongs to the Mucorini, consists of erect branching threads, many of the branches terminating in a delicate globose head or sporangium, containing numerous very minute sub-globose sporidia. This species has been named *Mucor hyalinus*. The habit is very much like that of the *Penicillium*, but without any roseate tint. It is almost certain that the *Mucor* could not have been present when the *Penicillium* was examined, and the leaves on which it had grown were unloosened in the tin box, but that the *Mucor* afterwards appeared on the same leaves, sometimes from the same patches, and from the same mycelium. The great difference in the structure of the two species lies in the fructification. . . . We entertain no doubt whatever that the *Mucor*, to which we have alluded as grown on box-leaves intermixed with *Penicillium roseum*, is no other than the higher and more complete form of that species, and that the *Penicillium* is only its conidiiferous state."

In our herbarium there are two packets of Cooke's "Fungi Brit.

Exs. No. 359," co-type material. The under sides of the leaves are still covered with a *Cephalosporium*-like growth bearing in heads small elliptical spores of variable size. We do not find any definite remains of a roseate *Penicillium* on these leaves, but on one leaf there were several perithecia well marked with stiff hyaline hairs capped with ruby-red drops like those found on the leaves of typical *Volutella Buxi* and noted above as ornamenting our green perithecia of *Nectriella Rousseliana*. Cooke's perithecia were reddish, rusty, amber or fulvous-colored. Definite asci were not present although a few ascospores were seen in crushed mounts. Very likely No. 359 is merely the *Cephalosporium* stage of *Volutella Buxi*, and the ascocarps present on one leaf are those of the perfect stage. Cooke's *Penicillium roseum* was probably *Volutella Buxi* mixed in perhaps with *Verticillium Buxi*. In support of this statement we have in our herbarium No. 254, J. E. Vize, Micro-fungi Britannici, "*Mucor hyalinus*." Here the leaves are well covered with *Verticillium Buxi* and some *Hyponectria*. Furthermore, Vize's No. 339 "*Penicillium roseum* Link" in the same set, is practically all *Volutella Buxi*. Vize's No. 191, Brit. Fungi, labeled *Mucor hyalinus* is mostly, if not all, *Verticillium Buxi*.

Many attempts have been made to germinate spores taken directly from asci of *Hyponectria Buxi* without success. A number of spores taken at different times from the heaps of spores extruded from ascocarps and therefore presumed to be ascospores did germinate. Cultures from these spores gave good *Volutella Buxi*, which would indicate that the spores were not ascospores of the *Hyponectria*. It still remains to prove by single ascospore cultures the connection between *H. Buxi*, the *Nectriellas* and their imperfect stages. A beautiful roseate species of *Penicillium* has recently developed on twigs and leaves of boxwood held a long time in a damp chamber. This species is also being studied culturally.

#### SUMMARY

Culture experiments have proved that, as Juel first reported, *Volutella Buxi* and *Verticillium Buxi* are distinct species. Attention is called to a number of exsiccati specimens variously dis-

tributed as *Penicillium roseum*, *Volutella Buxi*, *Verticillium Buxi*, *Mucor hyalinus* and otherwise. It was pointed out that the stiff hairs or setae of *Volutella Buxi* are often capped with ruby-red beads which harden on drying. Hairs of the same type are often present on ascocarps of *Nectriella Rousseliana* and this is taken as better proof for a connection between the two forms than their mere presence on the same leaves.

The great variability in the size of the conidia of the *Volutella*, the presence and absence of hairs on sporodochia, the early development of conidia in drops of water suggesting *Cephalosporium* or *Acrostalagmus*, the different rates of growth of certain isolates, the great change of growth types in cultures derived from transplants from old cultures, are all questions calling for further study. Regardless of whether we may be dealing with different races or even species of what we have referred to in this paper as "*Volutella*" on boxwood, there can be no question that Juel was right in saying that *Verticillium Buxi* is an entirely distinct species.

THE NEW YORK BOTANICAL GARDEN.

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## SACCARDO'S CONFUSION OF THE SPERMATIAL STAGE OF *S. DURIAEANA* AND *S. CURREYANA* WITH THE SPHACELIA STAGE OF *CLAVICEPS NIGRICANS*

H. H. WHETZEL

Tulasne (Ann. Sci. Nat. III 20: 51, pl. 4, fig. 15-22. 1853) described *Claviceps nigricans* occurring in the caryopsis of *Eleocharis* and *Scirpus*. He describes all three stages, spermatial, sclerotial and perithecial.

Saccardo, thirty years later (1880), having before him specimens later (1881) distributed in Roumeguere's *Fungi Gallici 1200* on *Carex paniculata* bearing sclerotia in the culm with spermodochidia above, mistook the fungus to be the sphacelia stage of Tulasne's *Claviceps nigricans*. He applied the name "*Sphacelia nigricans* (Tul.)" Sacc. to the spermatial fruit-bodies and published a description of them (*Michelia* 2: 131. 1880). In the same publication (p. 134) he applied the name "*Sclerotium nigricans* (Tul.)" Sacc. to the sclerotial stage but gave no description, saying merely "in culms of *Carex paniculata*." In his description of *Sphacelia nigricans* and *Sclerotium nigricans*, he cites Therry as the collector. It seems obvious, however, that these two names were based upon the same specimen. The label on Roumeguere Fung. Gall. 1200 reads "*Sclerotium nigricans* (Tul.) Sacc. *Michelia* VI p. 134 *S. sulcatum* p. *Nigricans* Th. in litt." The "VI" is an error for II.

It is obvious from an examination of the Roumeguere specimen, that the fungus involved is the spermatial and sclerotial stages of Tulasne's *Sclerotinia duriaeana* as Whetzel (*Mycologia* 21: 9) has already pointed out.

In 1883 Saccardo (*Syll. Fung.* 2: 565) re-published the Latin description of *Claviceps nigricans* Tul. describing the perithecial stage and the sclerotium, but making no mention of the sphacelia

stage. He gives as hosts, *Eleocharis* and *Scirpus* and the range, France, Germany and Britain.

Six years after Saccardo's erroneous application of his name *Sphacelia nigricans* he compounded his original error by publishing (Syll. Fung. 4: 666. 1886) the new combination *Sphacelia ambiens* (Desm.) Sacc. He refers to his original publication "Mich. II, p. 131," and cites "*Epidocium ambiens* Desm. XXII, Not. p. 19" and "*Sphacelia nigricans* Sacc. olim" as synonyms. Remarking "*Sclerotio incipienti Clavicepitis nigricantes*," he presents a description of the sclerotium and the spermatial fruit-body, saying this fungus occurs on *Carex paniculata* and "aliarum in Gallia."

To further complicate matters, Saccardo in 1884 (Misc. Myc. In Venezia Inst. Atti 6: 2: 448) having before him a specimen of the spermatial stage of a fungus on the culms of *Juncus glaucus*, gave it the name *Sphacelia tenella* Sacc. and described it, the description appearing two years later (1886) in his Sylloge (4: 666) on the same page as his description of *Sphacelia ambiens* (Desm.) Sacc. The fungus on *Juncus glaucus* to which he applied this name is undoubtedly the spermatial stage of *Sclerotinia curreyana* (Berk. in Currey) Karst. He would seem, however, to have previously believed it to be his *Sphacelia nigricans* since he begins his description in Miscellanea Mycologia, "*Sphacelia nigricans* (Tul.) Sacc. *S. tenella* Sacc.," while in the Sylloge the name "*Sphacelia nigricans*" is discarded.

It is clear that he still labored under the delusion that the fungus in Roumeguere's 1200 was identical with Tulasne's *Claviceps nigricans*.

Nor does Saccardo appear to have ever discovered or at least acknowledged his error for finally in 1899, he published a description of his *Sclerotium nigricans* (Syll. Fung. 14: 1153) citing the original place of publication but dating it 1882 (erroneously for 1880)<sup>1</sup> saying that it is the mycelium "quiescens" of *Claviceps nigricans* Tul. and citing as a synonym "*Scl. Eleocharidis* Thüm. M. N. n. 2298 (1883)." This citation also is erroneous: it should read "Thüm. M. U. 2298 (1884)." Following the very brief de-

<sup>1</sup> Although the cover page of Michelia, vol. 2, bears the date 1882, the first 176 pages were issued in 1880 as is also stated on the cover page.

scription of the sclerotium, he gives as the habitat *Carex paniculata* and *Eleocharidis palustris* and for its distribution France and Denmark. Then, as if to emphasize his error, he adds the remark—"Est *Sclerotium Clavicipites nigricantis*."

It is clear then that the names *Sphacelia nigricans* (Tul.) Sacc. and *Sclerotium nigricans* (Tul.) Sacc. must be used for the respective stages of *Claviceps nigricans* Tul. regardless of the fact that Saccardo had in hand the spermatial and sclerotial stages of *Sclerotinia duriaeana* (Tul.) Rehm. The name *Sphacelia ambiens* (Desm.) Sacc. on the other hand is to be regarded as Saccardo's name for the spermatial stage of *Sclerotinia duriaeana* in spite of the obvious fact that he thought it identical with his *Sphacelia nigricans*, while *Sphacelia tenella* Sacc. is the spermatial stage of *Sclerotinia curreyana* (Berk. in Currey) Karst.

In placing these names in synonymy it would appear most proper to cite them as follows:

***Claviceps nigricans* Tul.**

*Sphacelia nigricans* Sacc. *Michelia* 2: 131. 1880. specim. excl.

*Sclerotium nigricans* Sacc. *Michelia* 2: 134. 1880. specim. excl.

***Sclerotinia duriaeana* (Tul.) Rehm.**

*Sphacelia nigricans* sensu Sacc. *Michelia* 2: 131. 1880.

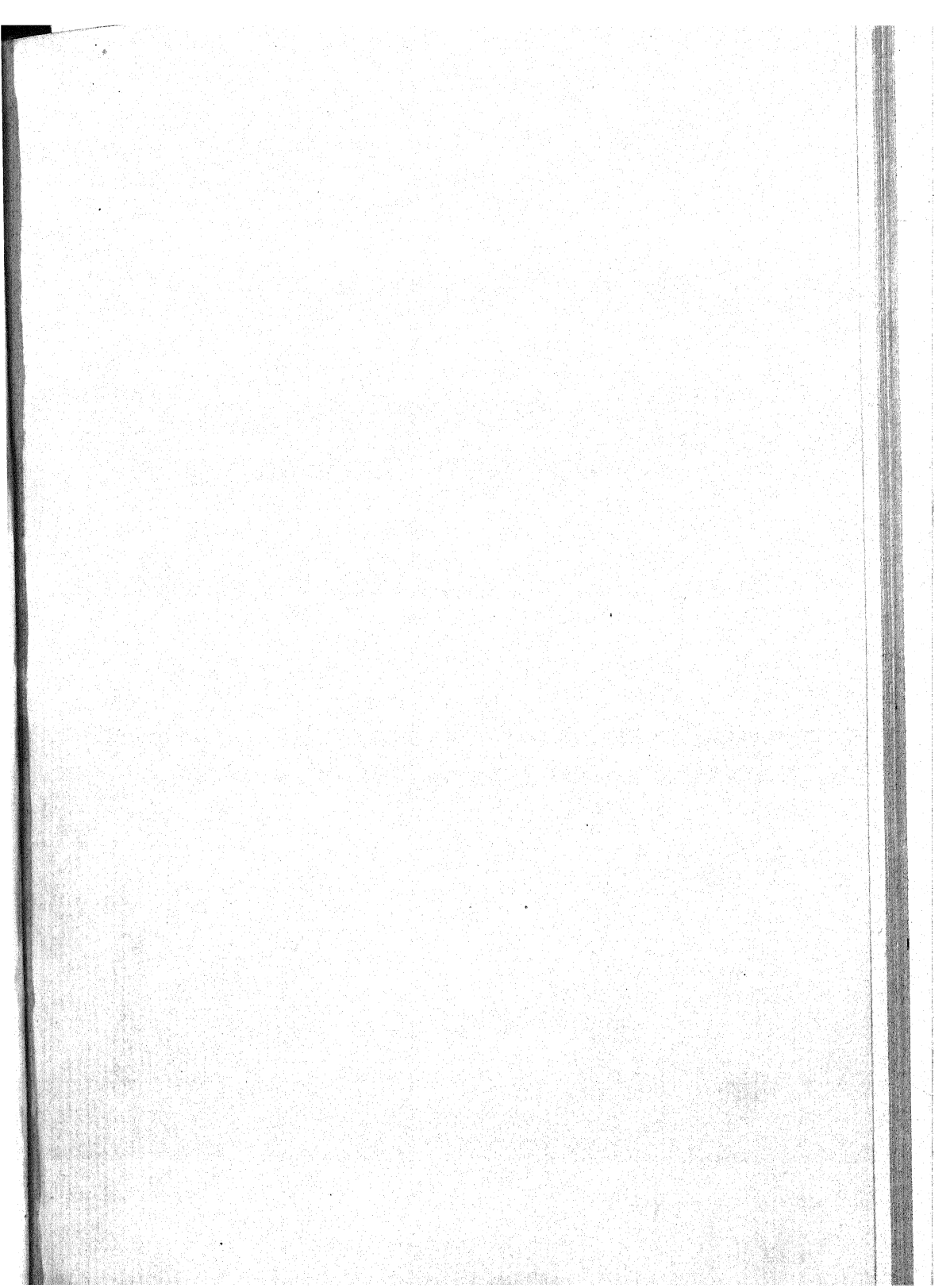
*Sclerotinia nigricans* sensu Sacc. *Michelia* 2: 134. 1880.

*Epidocium ambiens* Sacc. *Syll. Fung.* 4: 666. 1886.

***Sclerotinia curreyana* (Berk. in Currey) Karst. *Rev. Monogr.* 123. 1885.**

*Sphacelia tenella* Sacc. *Syll. Fung.* 4: 666. 1886. Sacc. *Pro. Syn. Venezia Inst. Atti* 6: 2: 448 (14). 1884.

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E. B. MAINS, PRESIDENT 1942  
MYCOLOGICAL SOCIETY OF AMERICA

# MYCOLOGIA

OFFICIAL ORGAN OF THE MYCOLOGICAL SOCIETY OF AMERICA

VOL. XXXVI SEPTEMBER-OCTOBER, 1944 No. 5

## NEW OR HERETOFORE UNREPORTED SPECIES OF THE HIGHER ASCOMY- CETES FROM COLOMBIA AND VENEZUELA<sup>1</sup>

CARLOS GARCÉS OREJUELA

During the last two decades there has been an increasing interest in the knowledge of the mycological flora of South America, especially of countries like Colombia and Venezuela, which of large geographical extent and with a great diversity of climatic conditions, offer to the mycologists an almost unexhaustable field for exploration, especially in regard to the great number and variety of species. The mycological explorations in these two countries however, have been relatively few, the most important contributions being those of Chardon, Toro and Kern (6, 7) to whom the author refers the reader for a more detailed account of the studies made on the subject in those countries.

The present paper is based largely on recent collections made by several persons, chiefly by Dr. Chardon and by the author in Colombia and by Drs. H. H. Whetzel, M. F. Barrus and A. S. Müller in Venezuela. These specimens are deposited in the Plant Pathology Herbarium of Cornell University, in separately numbered exsiccata sets, duplicates of the Colombian collections being kept at the herbarium of the Facultad de Agronomía, Medellín, and the herbarium of the Instituto de Ciencias Naturales, Bogotá, while

<sup>1</sup> Presented as a thesis for the master's degree at Cornell University. March 1944.

duplicates of those from Venezuela are deposited at the "El Valle" Agric. Exp. Station, Caracas.

In order to avoid constant repetition the letters "FC" will be used for the fungi from Colombia, and "FV" for those from Venezuela, while the abbreviations "Med." and "Bog." will be employed to designate the herbaria at Medellín and Bogotá, respectively; "FPR" will be used to designate specimens from the Fungi of Porto Rico in the Herbarium of the Department of Plant Pathology in Cornell University. The collections made by R. A. Toro in Colombia in 1927-28 and now in the herbarium of the Department of Plant Pathology at Cornell University are designated, "Toro FC," followed by his serial number. Specimens cited from the general collections of the same department will be designated "CUPP."

Fifty species are here reported; 38 from Colombia and 14 from Venezuela, two of them occurring in both countries. Sixteen are new species, the others being heretofore unreported or recorded for the first time on new hosts or from new localities.

The author wishes to acknowledge his deepest obligation to Professor H. H. Whetzel of the Department of Plant Pathology of Cornell, for his aid and encouragement in the work as well as for his suggestions and criticisms. Thanks are also due the Misses Ellen North and Stephanie M. Jakimowitz for their kind coöperation in the preparation of the latin diagnoses of the new species.

#### Order PERISPORIALES

Even though the number of species of the *Perisporiales* already reported in Colombia and Venezuela is rather small, this group of fungi, and specially some of its families appear to be very rich in number of species. This is to be expected on account of the tropical, humid conditions which favor the development of these forms. The *Erysiphaceae* on the other hand, many forms of which appear in the conidial stage, have rarely been found in the perfect stage. The order *Perisporiales* is considered here in the sense of Theissen and Sydow (32) but the *Meliolinæ* have been studied on the basis of Stevens' monograph (24, 25). The Beelian formulas of the new species here described have been established in accordance with the slight changes introduced by Stevens.

## Family PERISPORIACEAE

PSEUDOPARODIELLA VERNONIAE Stevens, Illinois Biol. Monog. 11<sup>2</sup>: 14. 1927.

On *Vernonia canescens* HBK.

COLOMBIA, Antioquia, Highway Medellín-Rionegro, K 7, 1800 m., Garcés, Dec. 3, 1941. FC 1560; Med. 273.

VENEZUELA, Miranda, San Antonio de los altos, M. F. Barrus and A. S. Müller, Dec. 8, 1939. FV 3660.

The specimens were compared with Stevens' type from Costa Rica. The Colombian and Venezuelan materials show a greater abundance of the conidial stage.

PARODIOPSIS STEVENSI Arnaud, Ann. Epiphy. 9: 22. 1923. *Perisporium truncatum* Stevens, pro parte.

On *Inga* sp.

COLOMBIA, Tolima, near Campoalegre, 1200 m., G. Quintana, Apr. 15, 1941. FC 1320; Bog. 903.

This fungus first described from Porto Rico where it seems to be common on *Inga* sps., is very conspicuous on the under side of the leaves in the form of smoky, black patches sometimes covering a great portion of the blade. As it is very probable that its geographical range is wider than what is now known, it appears desirable to clear up some facts of its history. Fries (10) created the genus *Perisporium* including 16 species, 9 of which Saccardo (Syll. Fung. 1: 58-60. 1882) considers as doubtful, the other 7 being excluded as synonyms, among them *Perisporium gramineum* which, due to the fact of its being the first described species, may be considered the type. Based on these considerations and on the fact that some of the species included by Saccardo under *Perisporium* prove to be Aspergillaceous, Theissen and Sydow (32: 448) dropped the genus from consideration. In the same year Stevens (22) described his *Perisporium truncatum* on *Inga laurina* (FPR 7049) with "spores 2-septate, cylindric, 68-92  $\times$  10  $\mu$ , hyaline when young, smoky or darker when old, rounded at one end, truncate and with a ring around the other end." Later on Arnaud (2) examined the material collected by Stevens and provisionally

erected (due to the absence of mature ascospores as stated in a foot-note) the species *Perisporina truncata* (Stevens) Arnaud, considering it as a synonym of *Perisporium truncatum* Stevens. Later Arnaud (3) studied the Porto Rican specimens collected by Whetzel and Olive (FPR 533 and 601) and determined by Chardon as *Perisporium truncatum* Stevens, and also no. 7049 of Stevens' collection (the type). Another specimen from Chardon's own herbarium, 616, was also studied. The four specimens were shown to be the same fungus, the first two mentioned being in a more advanced stage of maturity. The type specimen showed no ascospores. Chardon's 616 had some more mature perithecia with very few 1-septate spores resembling those found on FPR 533 and 601. None of the specimens showed the ascospores as described for *Perisporium truncatum*, which according to Arnaud (loc. cit.) are very similar to those of *Perisporina manaosensis*; Arnaud concluded by suggesting the possibility that a *Parodiopsis* might occur on the same leaves.

In the material examined he could find no fully mature ascospores, although some of them were mature enough to show the septation of the spores. These ascospores never had more than 1 septum, being hyaline, constricted at the septum and very variable in length and width, averaging  $50 \times 12 \mu$ . He subsequently erected the species *Parodiopsis Stevensi*, *pro parte*. In referring to *Perisporina truncata* (Stevens) Arnaud, Arnaud says: "The perithecia described by Stevens show by the character of the ascospores that they belong to a *Perisporina* but on the material sent we could only find the *Parodiopsis Stevensi*," and concludes that there were on the leaves of Stevens' specimen a *Parodiopsis* and a *Perisporina* with similar vegetative characters.

The author examined Stevens' type, 7049 (duplicate in CUPP 1266), and found that the ascospores, even the young ones, are 2 septate, all other characters being as described by Stevens. This fact establishes the validity of Arnaud's species *Perisporina truncata*. On the other hand an examination of the Porto Rican material (FPR 533, 601 and 602) shows the presence of the hyaline 1-septate ascospores of *Parodiopsis Stevensi* Arnaud. This leads the author to the conclusion that *Parodiopsis Stevensi* is a separate species and not the immature stage of *Perisporina truncata*, as

might be thought from the fact that both species are essentially alike except for the septation of the ascospores.

The Colombian material does not present mature ascospores either, but they are hyaline, 1-septate and very much like those on specimens FPR 533 and 602.

***Parodiopsis bicoronata* sp. nov.**

Colonies epiphyllous blackish, pulvinose, sometimes coalescent. Mycelium composed of straight, remotely septate brown-olivaceous hyphae, 9–10  $\mu$  thick, branched at long intervals. Stomopodia remotely separate, long ellipsoidal, simple, 10–12.5  $\mu$  wide. Perithecia dark brown, parenchymatic, astomous, globose, generally attached to the hyphae by a short foot, glabrous, 150–230  $\mu$  diam.; asci ovate 100–140  $\times$  50–62  $\mu$ , evanescent; ascospores conglobate, 1-septate, cylindrical, 72–94  $\times$  14–17  $\mu$ , hyaline when young, smoky brown when old, appearing truncate at both ends. Conidia 2-septate, hyaline with one end truncate.

On *Inga* sp.

COLOMBIA, Antiquia, Envigado, 1540 m., Garcés, Sept. 1942. FC 1814; Med. 560.

Coloniis hypophyllis pulvinosis, fuliginosis. Hyphis rectis fuscis-olivaceis, remotis septatis, 9–10  $\mu$  densis; stomopodiis remotis separatis, longe ellipsoideis, simplicibus 10–12.5  $\mu$  latis, 15–30  $\mu$  longis. Perithecia valde fuscis, parenchymatis, astomis, globosis, 150–230  $\mu$  diam.; ascis ovatis, 100–140  $\times$  50–62  $\mu$ , evanidis; sporidiis conglobatis 1-septatis, cylindraceutis, 72–94  $\times$  14–17  $\mu$ , fuscis, truncatis utrinque. Conidiis 2-septatis hyalinis, uno apice truncato.

While the general appearance of the present specimen is very much like *Parodiopsis Stevensi* Arnaud, there are several differences which seem to justify the erection of a separated species. These differences consist mainly in the color and septation of the mycelium, the cells of which are 45 to 180  $\mu$  long, while in *Parodiopsis Stevensi* they are 30–45  $\mu$  long. The shape of the stomopodia is also different; they are long ellipsoidal with acute apex, while those of *P. Stevensi* are almost clavate. The most distinctive character, however, is shown by the ascospores, which have a crown-like appearance at both ends, in contrast to *Parodiopsis Stevensi* which shows one end truncate and the other round.

DIMERIUM COSTARICENSE Syd., Ann. Myc. 24: 322. 1926.

Parasitic on mycelium of *Schiffnerula monotheca* (Pat. & Gaill.) Pat., on *Rapanea ferruginea* (R. & P.) May, vel. aff.

COLOMBIA, Antioquia, Guayabito, between Rionegro and Retiro, 2200 m., Garcés, Feb. 25, 1942. FC 1538; Med. 246.

IRENOPSIS MOLLERIANA (Winter) Stev., Ann. Myc. 25: 437. 1927.

On *Sida* sp.

COLOMBIA, Meta, Villavicencio, 480 m., E. Orjuela, Sept. 12, 1941. FC 1328; Bog. 916.

On *Sida acuta* Burn.

COLOMBIA, Meta, Campoalegre, near Villavicencio, E. Orjuela, Sept. 10, 1941. FC 1349; Bog. 937.

Our material presents small epiphyllous colonies, sometimes coalescent, scattered all over the leaf surface. The mycelium is reticulate, composed of rather crooked hyphae about  $7\mu$  in diameter, brown, with opposite branching. The capitate hyphopodia are ovoid or lobate, irregular or alternate. Mucronate hyphopodia are opposite. Perithecia about  $150\mu$  diameter, roughened, with 2 to 5 setae which are slightly curved, obtuse or acute and about  $85\mu$  long; asci evanescent; ascospores 4-septate, brown,  $35 \times 12.5\mu$ .

These Colombian specimens were compared with Stevens' specimens, 4184 on *Irenopsis Molleriana* (Winter) Stevens, with which they agree very well in all characters. Stevens and Tehon (Myco-*logia* 18: 21. 1926) described a new species, *Irene sidicola* on *Sida* sp. Later (25) Stevens reduced this to a variety under the name *Irenopsis Molleriana* var. *sidicola*. Judging from the original description of *Irene sidicola* it differs from our material in the character of the hyphopodia, in the number of perithecial setae, which is usually one and in the alternate branching of the mycelium.

IRENINA HYPTIDICOLA (Stevens) Stevens, Ann. Myc. 25: 455. 1927.

On *Hyptis capitata* Jacq.

VENEZUELA, Aragua, Rancho Grande, road Maracay to Ocumare, Chardón, Mar. 25, 1939. FV 2795.

***Irenina Pittieri*** (Toro) comb. nov.

*Irenopsis Pittieri* Toro, Mong. Univ. Porto Rico 2: 114. 1934.

The type FV 371 which is very poor and FV 522 have been examined without discovering perithecial setae. A new collection on



the same host in the same region, shows no perithecial setae either. This fact places the species in the genus *Irenina* rather than in *Irenopsis*. The conidiophores of the conidial stage arise very close to the perithecium, but they are easily distinguishable from the setae by frequently showing still attached conidia. In our material the perithecia reach  $325\ \mu$  in diameter and the ascospores are  $43\text{--}45 \times 18\ \mu$ .

On *Duranta repens* L.

VENEZUELA, Miranda, San Antonio de los Altos, M. F. Barrus and A. S. Müller, Dec. 8, 1939. FV 3664.

COLOMBIA, Boyacá, near Guateque, R. Obregón, Oct. 24, 1940. FC 1180; Bog. 623.

***Meliola antioquensis* sp. nov.**

Colonies epiphyllous, irregular, black, forming large patches on the leaf. Mycelium of straight, opposite branched hyphae,  $3\ \mu$  thick, dark-brown. Capitulate hyphopodia alternate or irregularly disposed; head cell oval to pyriform or cuneiform,  $15.5\text{--}17 \times 11\text{--}12\ \mu$ ; mucronate hyphopodia opposite, bottle shaped, with curved neck. Perithecial setae straight or slightly curved with simple tips, arising mostly at the base of the perithecium; mycelial setae similar, abundant, mostly  $260\text{--}360\ \mu$  long. Perithecia  $140\text{--}215\ \mu$  diam., slightly roughened; asci evanescent; ascospores 4-septate brown, strongly constricted at the septa, with obtuse ends,  $44\text{--}49 \times 15.5\text{--}18.5\ \mu$ . Beelian formula  $3411\text{--}4223\frac{1}{2}$ .

On *Persea petiolaris* H.B.K.

COLOMBIA, Antioquia, Sabaneta, near Medellín, 1540 m., Garcés, Oct. 9, 1942. FC 1828; Med. 573.

Coloniis epiphyllis nigris, irregularibus. Mycelio ex hyphis rectis valde fuscis composito. Hyphopodiis capitatis alternantibus vel irregularibus; hyphopodiis mucronatis oppositis lageniformibus. Perithecialibus setis rectis cum apicibus simplicibus ad basem peritheci plerumque; setis mycelialibus similaribus, abundantibus,  $260\text{--}360\ \mu$  longis. Peritheciis  $138\text{--}215$  diam.; ascis evanidis; sporidiis 4-septatis, fuscis, constrictis, obtusis,  $44\text{--}49 \times 15.5\text{--}18.5$ .

This species differs from *Meliola amphitricha* Fries in the character of the hyphopodia and in the size of the spores which are larger in our specimen. It also differs from *Meliola circinans* Earle in the shape of the hyphopodia which are circinate in the latter species.



MELIOLA HARIOTULA Speg., Rev. Agr. Hist. Nat. Buenos Aires 1: 1891.

On *Inga* sp.

VENEZUELA, Táchira, San Cristóbal, J. I. Otero, Oct. 28, 1933. FV 1644.

Known from Asunción (Paraguay) on leaves of an undetermined *Bignoniaceae* or *Leguminosae*. Our material presents colonies amphigenous, black, circular; mycelium dense, dark-brown formed by straight hyphae about  $9\ \mu$  thick, branching opposite, slightly constricted at septa. The capitate hyphopodia are opposite,  $16 \times 9\ \mu$ , curved, frequently recurved at the middle, with stock cell small and head cell elongated and sometimes lobed. The mucronate hyphopodia are very rare, lageniform. Mycelial setae very numerous, black,  $250\ \mu$  long, divided at tip into 2 or 3 short spreading branches. These branches are  $15\text{--}20\ \mu$  long and are simple or dentate at their tips. The perithecia are about  $200\ \mu$  diam., and more or less rough. The asci are bisporous and evanescent. The ascospores are 4-septate, elliptical with blunt ends, ventrally flattened, dark brown and mostly  $45 \times 19\ \mu$ . Beelian formula 3132-4221.

The type specimen has not been seen but the specimen agrees very closely with Gaillard's description (11) except that no pseudoostiolum as described by him, was observed.

MELIOLA LANTANAE Syd., Mem. Soc. Neufch. Sc. Nat. 5: 434. 1914.

On *Lantana fucata* Lindl.

COLOMBIA, Antioquia, Quebrada Iguaná, near Medellín, 1700 m., Garcés and de Rojas, Aug. 18, 1943. FC 1533; Med. 273. Robledo, near Medellín. FC 1841; Med. 586.

This is a rather common species already reported from Colombia where the type was collected. A new host is here recorded.

MELIOLA MAKILINGIANA Syd., Ann. Myc. 15: 188. 1917.

On *Sapanea glomerata* H.B.K.

VENEZUELA, Monagas, Maturín, M. F. Barrus, Jan. 24, 1940.  
FV 3820.

The material presents amphigenous colonies which are small, arachnoid and often confluent. The mycelium is formed by rather straight brown hyphae  $7.5\ \mu$  thick. The capitate hyphopodia are unilateral or alternate, one for each cell. The mycelial setae are crowded around the perithecia, erect,  $260\text{--}293\ \mu$  long, straight or somewhat curved with blunt or slightly swollen apices, sometimes bifurcated (branches 9–12). A new collection made by the author on the same host shows an abundance of setae. The perithecia were found to be up to  $300\ \mu$  diam.; the perithecial setae  $120\ \mu$  long, simple, and the mycelial setae  $150\ \mu$  long, also simple. The ascospores in the new material show a range of  $36\text{--}39 \times 12\text{--}15\ \mu$ .

MELIOLA PSIDII Fries, Linnaea 5: 549. 1830.

On *Psidium* sp.

COLOMBIA, Meta, Cano Moroco near Villavicencio, E. Orjuela,  
Sept. 12, 1941. FC 1334; Bog. 922.

**Meliola venezuelana** sp. nov.

Colonies amphigenous but more developed in the upper surface of the leaf, smoky when young, black when well developed, scattered over the leaf surface, isolated or confluent, circular or irregular in outline. Mycelium formed by light brown, slightly wavy hyphae; branching opposite; hyphal cells  $28\text{--}34\ \mu$  long,  $8\ \mu$  wide, monohyphopodiate. Capitate hyphopodia regularly spaced, alternate, seldom unilateral, stipitate; basal cell rectangular or trapezoid,  $5.6\text{--}6.5\ \mu$  long,  $8\ \mu$  wide; head cell cylindrical or slightly clavate, straight, sometimes slightly curved or hooked,  $12.5\text{--}15.5 \times 8.5\text{--}9.5\ \mu$ . Mucronate hyphopodia ampulliform, opposite,  $18.5\text{--}22\ \mu$  long  $\times 8\ \mu$  thick at the base, with a straight neck  $12.5 \times 3\ \mu$ . Perithecia abundant, scattered, spherical or slightly depressed, more or less pellucid with walls distinctly visible, only slightly rough; the larger ones  $200\ \mu$  diam. Discal setae surrounding the perithecia, erect or sub-erect,  $535\ \mu$  long, straight or amply curved, simple,  $9\ \mu$  at the base and gradually tapering toward the apex which is  $6\ \mu$  thick. Mycelial setae similar to discal setae but scarce; asci 3-spored, evanescent; ascospores 4-septate, cylindrical with blunt ends, slightly constricted at the septa, brown,  $44\text{--}45.5 \times 15.5\text{--}18\ \mu$ . Beelian formula  $311/3\ 1:5222/3$ .

On *Pithecolobium ligustrinum* Klotz.

VENEZUELA, Anzoátegui, Barcelona, M. F. Barrus, Feb. 1, 1940.  
FV 3817.

Coloniis amphigenis, plerumque epiphyllis, circularibus vel irregularibus. Mycelio opposito ramoso  $8\mu$  crasso; hyphopodiis capitatis alternantibus raro unilateralibus, stipitatis, cellula inferiore aut rectangula aut trapezoide  $5.6-6.5\mu$  longa,  $8\mu$  lata; cellula capitata cylindraceae vel subclavata, aliquando curvata,  $12.5-15.6 \times 8.5-9.5\mu$ ; hyphopodiis mucronatis lageniformibus oppositis,  $18.5-22\mu$  longis. Peritheciis numerosis, globosis, subpellucidis,  $200\mu$  diam.: setis discalibus erectis,  $535\mu$  longis, vel rectis vel valde curvatis, simplicibus cum apice vel obtuso vel dentato; setis mycelialibus similaribus; ascis 3-sporis, evanidis. Sporidiis 4-septatis, cylindricis, constrictis, fuscis,  $44-45.5 \times 15.5-18\mu$ .

**Meliola xylosmicola** sp. nov.

Colonies epiphyllous black, circular with radiating margins, 2-3 mm. diam., partially deciduous. Mycelium consisting of brown, opaque, straight hyphae  $8-10\mu$  thick; cells generally  $25-30\mu$  long; branching opposite at acute angle. Capitulate hyphopodia alternate, one to each cell, stipitate,  $22 \times 11\mu$ , generally forming an angle of  $45^\circ$  with the hyphae; basal cell small,  $4 \times 9\mu$ , trapezoid; head cell cylindrical or slightly club-shaped, straight or slightly curved, entire. Mucronate hyphopodia rather scarce, opposite, located near the center of the colony, crowded,  $15-24 \times 9-10\mu$ , ampulliform, contorted, frequently opposite a capitulate hyphopodium. Mycelial setae scattered or numerous near the perithecial disk, simple, straight, about  $570\mu$  long,  $10\mu$  thick at the base, gradually tapering toward the apex which is pellucid, blunt and  $6\mu$  thick. Perithecia isolated, globose, black, slightly roughened, about  $215\mu$  diam. the larger ones, surrounded by discal setae similar to the mycelial setae but usually shorter,  $250\mu$  long; asci 2-spored, evanescent; ascospores 4-septate, broadly cylindrical with obtuse ends, constricted at the septa, brown,  $52-59 \times 22-24\mu$ . Beelian formula 3111-5323.

On *Xylosma spiculiferum* (Clos.) Triana & Pl.

COLOMBIA, Cundinamarca, hills above Facataivá, Chardón, Mar. 28, 1937. FC 1076.

Coloniis epiphyllis nigris, circularibus cum marginibus radiatis, 2-3 mm. diam. Hyphis fuscis,  $8-10\mu$  crassis, ramis oppositis in angulo acuto; hyphopodiis capitatis alternantibus stipitatis,  $22 \times 11\mu$  longis, cellula basali trapezoidea, cellula superiore cylindracea vel clavata; hyphopodiis mucronatis raris, ampulliformibus. Setis mycelialibus simplicibus, rectis,  $570\mu$  longis, apice obtuso. Peritheciis disuntis, globosis,  $215\mu$  diam., circumdati ab setis discalibus similaribus setarum mycelialium, sed  $250\mu$  longis. Ascis 2-sporis evanidis. Sporiis 4-septatis, cylindraceis, obtusis, constrictis,  $52-59 \times 22-24\mu$ , fuscis.

The present species differs from *Meliola Xylosmae* Stev. in the size of the spores which are larger. The species is near *M. Banarae* Stev. from which it differs in the shape of the hyphopodia and the presence of discal setae. The Colombian species also differs from all other species of *Meliola* reported on *Flacourtiaceae* in having much larger spores and setae.

#### Family TRICHOthyRIACEAE

TRICHOthyRIUM DUBIOSUM (Bom. & R.) Theiss., Boih. Bot. Centralb. 32: 8. 1914.

On *Irenina hyptidicola* (Stevens) Stevens, on *Hyptis capitata* Jacq., Chardón, Mar. 25, 1939. FV 2795.

On undetermined *Meliolinac*.

VENEZUELA, Monagas, LaPica, Maturín, M. F. Barrus, Jan. 25, 1940. FV 3797.

The thyriothechia are 84–145  $\mu$  in diameter. The asci are 45–50  $\times$  12–15  $\mu$  and the ascospores are clavate, 15.6–17  $\times$  3.5–3  $\mu$ , the superior cell broader. The conidial tetrads are smooth-walled, about 12  $\mu$  in diameter and rather abundant.

#### Family ENGLERULACEAE

SCHIFFNERULA MONOTHECA (Pat. & Gaill.) Petrak, Ann. Myc. 26: 397. 1928.

*Questaeria monotheca* (Pat. & Gaill.) Arnaud, Ann. Ecole Nat. Agric. Montpellier 16: 187. 1918.

On *Rapanea ferruginea* (R. & P.) May *vel affinis*.

COLOMBIA, Antioquia, Guayabito, between Rionegro and Retiro, Garcés, Feb. 25, 1942. FC 1538; Med. 246.

Previously recorded in Venezuela and Brazil. Petrak (18) considers the genera *Questaeria* and *Phaeoschiffnerula* synonyms of *Schiffnerula*. The present specimen presents very slight differences from Theissen's description of *Balladyna monotheca* (Pat. & Gaill.) Theiss. (subsequently changed to *Questaeria monotheca* by Arnaud) and therefore does not justify the erection of a new species. Arnaud's plate (1) shows the ascospores spiny, a fact that is not mentioned by previous authors, while the Colombian

material presents ascospores with smooth epispore. The spore-wall is rather thick, the outer layer hyaline and refringent, the inner layer clearly brown. The ascospores are a little larger and broader than described, the inferior cell being  $36\text{--}44\ \mu$  long  $\times$   $20\text{--}22\ \mu$  wide, the superior one  $18\text{--}20\ \mu$  wide; both cells are almost equally long.

*Schiffnerula Rubi* Syd., described as having only one ascus, has smaller spores.

***Schiffnerula robusta* sp. nov.**

Colonies epiphyllous, circular, 4 mm. in diameter, scattered or sometimes confluent, black. Mycelium composed of irregularly and frequently ramified and septate hyphae, yellowish brown in color and rather straight,  $10\ \mu$  thick. Capitulate hyphopodia very abundant in the center of the colony, crowded together, more spaced in the margins of the colony, unilateral or alternate, one celled, subglobose,  $15\text{--}17\ \mu$  wide  $\times$   $13\text{--}17\ \mu$  high, sometimes very slightly lobed. Perithecia numerous, scattered or loosely gregarious, sometimes aggregated, globose or globose-ellipsoidal, the larger ones  $92\text{--}170 \times 92\text{--}110\ \mu$ ; perithecial roof made of angular or ellipsoidal cells which appear loose after disintegration of the wall at maturity; asci 4-6, broadly ovate or globose, with thickened apices, 8-spored,  $72\text{--}88 \times 56\text{--}62\ \mu$ ; ascospores conglobate, oblong-ovate or ellipsoidal with both ends broadly obtuse, septate near the middle, more or less constricted at the septa, hyaline at first then smoky brown with smooth epispore,  $32\text{--}34 \times 17\text{--}18.7\ \mu$ .

On *Rapanea* sp.

COLOMBIA, Cundinamarca, Páramo de Chipaque, Chardón, Apr. 1, 1937. FC 1122.

Coloniis epiphyllis, circularis, 4 mm. diam. nigris. Hyphis saepe ramosis, saepe septatis,  $10\ \mu$  crassis; hyphopodiis capitatis abundantibus, congestis in media colonia, unilateralibus vel alternantibus, simplicibus, globosis,  $15\text{--}17\ \mu$  latis  $\times$   $13\text{--}17\ \mu$  longis; peritheciis numerosis, globosis vel ellipsoideis,  $92\text{--}170 \times 92\text{--}110\ \mu$ ; disintegrantibus maturis; ascis 4-6, late ovatis vel globosis, 8-sporis,  $72\text{--}88 \times 56\text{--}62\ \mu$ ; sporidiis conglobatis, ovatis vel ellipsoideis, 1-septatis, constrictis, fuscis,  $32\text{--}34 \times 17\text{--}18.7\ \mu$ .

Order HEMISPHERIALES

In general the criterion of Theissen and Sydow presented for the *Hemisphaeriales* in the *Synoptische Tafeln* (32) has been regularly followed in the treatment of the order, with very slight modifications which have been made in order to include the family, *Micropeltaceae* and later erected genera. In doing this the author

follows the leaders in this group, who still consider the general arrangement of that work the most appropriate treatment, in spite of the several papers which have appeared proposing taxonomic changes in the order. Consequently the generic characters established by Theissen and Sydow have been followed, except in the case of the genera *Asterina* and *Parasterina*, which they separated on account of the presence or absence of paraphyses. The difficulty of applying this criterion to species in these genera is so great, in most cases, that it can not be considered a reliable character for distinguishing between them. This fact was pointed out early by Theissen (29) in the following paragraph: "The presence or absence of paraphyses can no longer be admitted as a principle, at the same time practical and scientific; not only because it is frequently difficult to verify the presence of true paraphyses and to distinguish them from other interthecial hyphae, but also because such a division would separate species closely related by the combination of their other characters."

Furthermore, mycologists like Petrak (17) consider that the presence or absence of paraphyses or paraphysoids alone is a character which can not be used as a generic distinction between hemisphaeric forms. This criterion is also held and emphasized by Doidge (9) who merges the two genera, *Asterina* and *Parasterina* into one, *Asterina*, and retains the other name as a section. The author follows Doidge in considering only the genus *Asterina* whether or not the species has paraphyses, but is unaware of the significance of this character among other genera of this order. The necessity for a revision of the group and for a better discussion of the generic characters in the order is imperative.

#### Family POLYSTOMELLACEAE

POLYSTOMELLA COSTARICENSIS Stevens, Illinois Biol. Monog. 11<sup>2</sup>:  
23. 1927.

On *Struthanthus* sp.

VENEZUELA, Caracas Agric. Exp. Sta., F. Tamayo, Apr. 3, 1939.  
FV. 3461.

This specimen was compared with the type, Stevens' 255 from Costa Rica (CUPP 14710), with which it agrees very well.

**Polyrhizon Capparidis** sp. nov.

Colonies epiphyllous superficial, black, crustaceous, circular, 1-5 mm. in diameter, formed by many ascostromata. Thyriothecia black, radiate with entire margins, about  $300\ \mu$  diam., and  $90\ \mu$  high, attached to the leaf by a central epidermal hypostroma up to  $120\ \mu$  thick; asci 8-spored, obovate, with thickened apices when young, broadly cylindrical at maturity, very shortly stipitate, paraphysate,  $47-60 \times 18-25\ \mu$ ; ascospores brown, distinctuous or inordinate, ellipsoid with round ends, septate near the middle, strongly constricted at the septum, superior cell broader,  $21-24 \times 8-9\ \mu$ . Paraphyses simple or ramified at tips.

On *Capparis flexuosa* Blume.

VENEZUELA, Caracas, A. S. Müller, Sept. 12, 1939. FV 3501.

Maculis epiphyllis circularibus, nigris, 1-5 mm. diam. Thyriotheciis  $300\ \mu$  diam.,  $90\ \mu$  altis, a centrale hypostroma epidermale ad folium adiunctis. Ascis 8-sporatis, ovobatis immaturis, late cylindricalibus maturis, paraphysatis,  $47-60 \times 18-25\ \mu$ ; sporidiis fuscis, ellipsoideis cum rotundis apicibus, septatis prope medium, ad septum fortiter constrictis,  $21-24 \times 8-9\ \mu$ . Paraphysibus simplicibus vel ramosis cacuminibus.

RHAGADOLOBIUM CUCURBITACEARUM (Rehm) Theiss. & Syd.,  
Ann. Myc. 12: 275. 1914.

On *Cucurbita maxima* Duch.

COLOMBIA, Antioquia, Rio Nus., near El Limón, 750 m., S. Arango,  
et al., Mar. 14, 1942. FC 1600; Med. 324.

A conspicuous form fairly common in the tropics.

Family MICROTHYRIACEAE

**Microthyrium Phoradendri** sp. nov.

Colonies amphigenous, more abundant on the underside of the leaves. Ascomata black, circular, superficial, isolated. Free mycelium subhyalin or slightly brown, non-hyphopodiate. Thriothecia radiate, dark brown with lighter center, non-fimbriate border and round pore at the center,  $270-300\ \mu$  in diameter; asci paraphysate, stout, broadly cylindrical tapering toward both ends, with rounded apex,  $69-72 \times 14-15\ \mu$ ; ascospores  $15.5-18.5 \times 6\ \mu$ , hyaline distinctuous, clavulate with both ends rounded, septum above the middle and constricted superior cell broader, inferior elongated tapering toward the end.

On *Phoradendron* sp.

COLOMBIA, Cundinamarca, Quipile, R. Obregón et al., Apr. 15, 1940. FC 1167; Bog. 422.

Coloniis amphigenis in hypophyllo abundantiore. Thyriothecia nigra, circulare, cum foramine circulare, 276–300  $\mu$  in diam.; ascis paraphysatis late cylindraceutis cum apice rotundato, 69–72  $\times$  14–15  $\mu$ ; sporidiis distichis, clavatis, uniseptatis, hyalinis, cellula superiore latiore, cellula inferiore elongata, 15.5–18.5  $\times$  6  $\mu$ .

This species differs from *Microthyrium Loranthe* (Karst. & Heriot) Theiss., in the size of the thyriothecia and the ascospores.

***Microthyrium rhombisporum* sp. nov.**

Colonies epiphyllous black, circular, aggregated in spots or scattered all over the leaf surface. Free mycelium none or slightly exceeding the fruit body, non-hyphopodiate. Thyriothecia isolated or confluent, applanate, radiate, dark brown or blackish, sometimes greenish, formed of elongated parenchymatic cells which form a fimbriate margin about 75  $\mu$  wide; 340–414  $\mu$  diam. including the marginal band; pore central, circular; asci obovate or oblong—pyriform sessile, 8-spored with thickened apex, involved in a mucous mass (apapophysate?), 62–68  $\times$  19  $\mu$ ; ascospores distichous or inordinate, rhomboidal, septate near the middle, both ends acute, superior cell broader, inferior cell pointed, not constricted at septum, hyaline, 17–20  $\times$  6.5–7  $\mu$ .

On *Rapanea* sp.

COLOMBIA, Antioquia, Robledo near Medellín, 1800 m., Garcés, Dec. 1942. FC 1853; Med. 598.

Coloniis epiphyllis nigris, rotundatis. Libero mycelio nullo. Thyriothecias separatis, raro confluentibus, ostiolatis, 340–415  $\mu$  diam., cum margine fimbriato 75  $\mu$  lato; ascis obovatis, sessilibus, 8-sporis (apapophysatis?) 62–68  $\times$  19  $\mu$ ; sporidiis rhomboideis, ad medium septatis, untraque cacumine acuto, cellula superiore latiore, hyalinis, 17–20  $\times$  6.5–7  $\mu$ .

This species differs from all other species of the genus described. No species has been reported on *Myrsinaceae*.

***Asterinella Bredemeyerae* sp. nov.**

Colonies punctate, epiphyllous, isolate or confluent, black, 2–3 mm. in diameter. Mycelium scarce, non-hyphopodiate, slightly reticulate. Hyphae branching sparsely, light brown, 3–4.5  $\mu$  thick, sub-nodulose in places and frequently septate. Thyriothecia abundant in each colony, rather circular in outline, 185–245  $\mu$  diam., with convex, radiate covering membrane, at first light colored, finally dark brown, with shortly fimbriate margin and stellate dehiscence;



asci numerous, ovate when young and broadly cylindrical at maturity, 8-spored, broadly round above, sessile,  $47-63 \times 15-19 \mu$ ; ascospores distichous or conglobate, oblong with both ends rounded, septate near the middle, slightly constricted at septum, buffy-olive in color, smooth,  $19-22 \times 6.5-9 \mu$ , superior cell broader and shorter. Paraphyses present, filiform.

On *Bredemeyera lucida* (Benth.) Kil.

VENEZUELA, Carabobo, Las Trincheras, M. F. Barrus & A. S. Müller, Feb. 24, 1940. FV 3846.

Coloniis punctatis, frequentissime epiphyllis, nigris, 2-3 mm. diam. Mycelio raro, non-hyphopodiato. Hyphis parce ramosis,  $3-4.5 \mu$  densis, frequenter septatis, subfuscis. Thyriotheciis abundantibus, circularibus,  $185-245 \mu$  diam., marginibus fimbriatis, stellatis dehiscentibus, valde fuscis. Asci numerosi, ovatis immaturis, late cylindricalibus maturis; 8-sporatis,  $47-63 \times 15-19 \mu$ ; sporidiis distichis, oblongatis, septatis prope medium, leniter constrictis ad septum, fuscis-olivaceis,  $19-22 \times 6.5-9 \mu$ ; superiore cellula latiore. Paraphysibus filiformibus.

ASTERINELLA WINTERIANA (Pasch.) Theiss., Brot. 10: 122. 1912.

*Prilleuxina Winteriana* Arnaud, Ann. Ecole Nat. Agric. Montpellier 16: 162. 1918.

*Asterina Winteriana* Pasch., Hedwigia 31: 104. 1892.

*Asterina anonicola* P. Henn., Hedwigia 41: 108. 1902.

The genus *Prilleuxina* was erected by Arnaud (1) on the grounds that the internal mycelium is connected only with the ascostroma and not with the hyphae of the external mycelium. Strangely enough, Stevens and Ryan (26) without amending the original diagnosis make no mention of this fact but separate the genus from *Asterinella* on account of the absence of paraphyses and include under *Prilleuxina* Arnaud, the aparaphysate species of *Asterinella*. As the location of the internal mycelium, in the writer's opinion, does not constitute a generic character, there appears to be no basis for the segregation. On the other hand, as the paraphyses alone are of no generic significance as a distinction between hemisphaeric forms, the author, as we have already said, is inclined to consider, along with Doidge (9: 275), that *Prilleuxina* must be united with *Asterinella*.

On *Anona muricata* L.

VENEZUELA, Carabobo, Las Trincheras, A. S. Müller, Jan. 23, 1940. FV 3792.

The specimen presents only the conidial stage *Leprieurina Winteriana* Arn. Apparently this is the third report ever made of this conidial stage. The conidia are  $28-37 \times 16-23 \mu$ , a little larger than described by Arnaud, but all other characters agree very well with the original description.

ASTERINA ANTIOQUENSIS (Toro) chart. amend.

*Asterinella antioquensis* Toro, Jour. Agr. Porto Rico 14: 232. 1940.

*Prilleuxina antioquensis* (Toro) Ryan, Illinois Biol. Monog. 17: 80. 1939.

Colonies epiphyllous, roundish, numerous, frequently anastomosing to form large black patches. Thyriothecia isolated or confluent,  $150-200 \mu$  in diam., circular, radiate, with black center and brownish border; marginal hyphae separate leaving round free spaces of the leaf surface exposed giving the stroma a perforated appearance; dehiscence by disintegration of the apical cells; hyphopodiate mycelium brown, wavy, formed by a net of anastomosing, thick walled, septate hyphae  $5-6 \mu$  thick; hyphopodia alternate, simple, oval or ellipsoid,  $7-9 \times 6-7 \mu$ ; asci broadly ovate, thick walled, sessile with thickened apex and round base,  $53-69 \times 31-40 \mu$ ; ascospores conglobate, unequally 1-septate, slightly constricted at the septum,  $23-25 \times 11-12.5 \mu$ , hyaline at first but fuscous at maturity, lower cell sphaerical, broader than the upper ellipsoid cell. Paraphysoids filiform, hyaline.

On *Miconia ciliata* (L. C. Rich) DC.

COLOMBIA, Antioquia, Angelópolis, July, 1927. Toro's FC 246.

On *Miconia theaezans* (Bonp.) Naud.

COLOMBIA, Antioquia, Robledo near Medellín, Garcés, Dec. 27, 1939. FC 1202; 1159; Bog. 671 and 412. Garcés, Dec. 3, 1941. FC 1550.

Coniis epiphyllis, rotundis, numerosis anastomosantibus. Thyriotheciis rotundis, nigris, perforatis ad marginem,  $150-200 \mu$  diam; mycelio fusco tortuoso, anastomosanti,  $5-6 \mu$  crasso; hyphopodiis alternantibus, simplicibus, ellipsoideis,  $7-9 \times 6-7 \mu$  ascis late ovatis, pariete cum crasso, sessilibus,  $53-69 \times 31-40 \mu$ ; sporidiis conglobatis 1-septatis, fuscis, cellula inferiore globosa, superiore ellipsoidea,  $23-25 \times 11-12.5 \mu$ ; paraphysoidibus filiformibus.

An examination of Toro's specimen (FC 246) shows that the fungus has hyphopodia; the species then must be transferred to *Asterina*. According to Toro's key of *Asterina* species on *Melastomaceae* (33) the present species falls near *Asterina Schlechteriana* Syd., and *Asterina venezuelana* Syd., but Sydow's descriptions of both of these leaves no doubt that the present species is quite different.

ASTERINA DIPLOCARPA Cooke, Grevillea 10: 129. 1882.

*Asterina similis* Cooke, Grevillea 10: 130. 1882.

*Asterina Sidae* Earle, Bull. N. Y. Bot. Gard. 3: 310. 1905.

*Asterina sidicola* Ryan, Mycologia 16: 181. 1924.

Toro (7) considers the last three mentioned species as synonyms of *Asterina diplocarpa* Cooke. A comparison of the original description of these three species shows that they differ only in unimportant characters, mainly in the size of the ascospores. As Toro found one specimen with variable ascospores measurements, it seems that his assumption is correct. Our specimen was compared with the Venezuelan specimens FV 511, 556 and 756 and was found to agree very well with them all.

On *Sida* sp.

COLOMBIA, Meta, Villavicencio, E. Orjuela, Sept. 12, 1941. FC 1328; Bog. 916.

On *Sida acuta* Burm.

COLOMBIA, Meta, Villavicencio, 480 m., E. Orjuela, Sept. 10, 1941. FC 1349; Bog. 937.

ASTERINA LIBERTIAE Syd., Ann. Myc. 2: 167. 1904.

On *Iris* sp.

VENEZUELA, Táchira, Páramo "La Negra," M. F. Barrus and A. S. Müller, Nov. 13, 1939. FV 3653.

The specimen agrees very well with the description given by Theissen in his monograph of the genus (30). The mycelium is composed of wavy brownish hyphae  $5\ \mu$  thick, which form a reticulate pattern. The hyphopodia are simple, alternate, straight or curved and sometimes lobed,  $9\ \mu$  long. The ascospores are echinulate, ovate-globose, mostly  $28 \times 13\ \mu$ , slightly constricted at the septum and with the superior cell slightly broader.

ASTERINA MEGALOSPORA Berk. & Curt., Jour. Linn. Soc. 10: 373. 1869.

*Asterina cubensis* Sacc. & Syd. in Sacc., Syll. Fung. 14: 698. 1899.

*Asterella Passiflorae* P. Henn., Hedwigia 43: 82. 1904.

*Asterina Passiflorae* Sacc., Syll. Fung. 17: 877. 1905.

These synonyms are given by Theissen (30); Sydow (28) gives also the following synonyms:

*Asterina confertissima* Speg., Bol. Acad. Nac. Cienc. Cordoba 23: 572. 1919.

*Asterina Tacsoniae* Pat. var. *Passiflorae* Ryan, Mycologia 16: 183. 1924.

*Asterina perconferta* Trott. in Sacc., Syll. Fung. 24: 466. 1926.  
On *Passiflora mollissima* (H.B.K.) Bailey.

COLOMBIA, Antioquia, Santa Helena, near Medellín, 2600 m., Garcés et al., June 17, 1941. FC 1400; Bog. 1145.

This species was previously reported in Colombia by Chardón and Toro (6); a new locality is here recorded. The specimen presents some differences from the Colombian material FC 653 and the Venezuelan FV 497. The ascospores are smaller in these two specimens and the hyphopodia of the last mentioned are mostly alternate whereas in our specimen they are most frequently opposite or one-sided. Furthermore, many spores present a spiny episporium when old.

ASTERINA MELANOTES Syd., Ann. Myc. 27: 59. 1929.

*Parasterina melanotes* Toro, Bol. Soc. Esp. Hist. Nat. 33: 196. 1933.

On *Miconia granulosa* (Bonp.) Naud.

COLOMBIA, Antioquia, Robledo, near Medellín, 1740 m., Garcés, June 15, 1941. FC 1370; Bog. 1115.

The type, from Costa Rica, has not been seen. Two species of *Asterina* occurring on *Melastomaceae*, with lobed hyphopodia, have been described (33), *Asterina* (*Parastcrina*) *Montagnei* Torø, and *Asterina melanotes* Syd. Our material was compared with the

first mentioned (Toro's FC 321); they differ in the character of the mycelium and the thyriothecia which in the present species lack the long basal radiating hyphae which characterizes *P. Montagnei*. On the other hand, while the present specimen presents some differences with the original description of *P. melanotes*, most of the general characters agree very well.

ASTERINA PHENACIS Syd., Ann. Myc. 25: 66. 1927.

On *Phenax hirtus* Wedd.

COLOMBIA, Valle, Highway Cali-Mar, K. 18, Garcés, Nov. 17, 1940. FC 1266.

**Asterina Solanacearum** sp. nov.

Colonies mostly epiphyllous, black, circular, 2–5 mm. in diameter, scattered all over the leaf surface and sometimes confluent. Mycelium radiate, tortuose, anastomose-reticulate brown,  $3.5\ \mu$  thick, with alternate or unilateral, simple, conoid, curved or irregularly shaped hyphopodia  $8\text{--}9\ \mu$  long and  $3.5\ \mu$  wide. Thyriothecia brown with a violet hue when aged, distinctly radiate throughout the entire covering,  $140\text{--}300\ \mu$  diameter, circular with fimbriate margins, dehiscing stellately with finally complete destruction of the perithecial roof; asci evanescent at maturity; ascospores brown 1-septate, smooth, constricted at the septum,  $28 \times 14\text{--}15.5\ \mu$ , with obtuse ends, superior cell slightly larger.

On *Solanum* sp.

COLOMBIA, Cundinamarca, Páramo de Guasca, Garcés et al., Oct. 1939. FC 1203; Bog. 672.

Coloniis plerumque epiphylliis, nigris, rotundatis, aliquando confluentibus, hyphis radiantibus, tortuosis, anastomoso-reticulatis,  $3.5\ \mu$  crassis; hyphopodiis alternantibus vel unilateralibus, simplicibus, conoideis, curvis vel irregularibus,  $8\text{--}9 \times 3.5\ \mu$ ; thyriotheciis  $140\text{--}300\ \mu$  diam.; ascis evanidis; sporidiis fuscis uniseptatis, constrictis ad septum,  $28 \times 14\text{--}15.5\ \mu$  cellula superiore lente maiore.

The present species differs from the other species reported on the *Solanaceae* either in the shape and distribution of the hyphopodia or in the size of the ascospores and perithecia. Comparisons were made with *Asterina coriacella* Speg., FPR 2512 and with *Asterina diplocarpa* Cooke, FPR 2528. Reported by Toro (6) under *Asterina diplopoda* Sydow, from which it differs in having only one kind of hyphopodia and larger spores.

**Lembosia Perseae** sp. nov.

Colonies epiphyllous forming definite spots 0.5–1 cm. in diameter. Ascstroma superficial, black, elongate and narrow, up to 1 mm. long  $\times$  0.1 mm. wide, sometimes coalescing. Mycelium  $3\ \mu$  thick, thick walled, brown pellucid, remote septate, straight or slightly tortuose, anastomose-reticulate. Hyphopodia scarce or none toward the center of the colony, more abundant at the margin and in young colonies, simple, ovoid, globose or bilobate,  $5\text{--}6\ \mu$  wide,  $3\text{--}6\ \mu$  high; asci globose  $28\text{--}34 \times 15.5\text{--}18.5\ \mu$ , 8-spored, paraphysate; ascospores brown, 1-septate,  $14\text{--}16 \times 6.5\text{--}8.5\ \mu$ , constricted at the septum, with obtuse ends, superior cell broader.

On *Persea* sp.

COLOMBIA, Antioquia, "La Leguna" above Medellín, 2500 m., A. Yepes, July, 1942. FC 1642; Med. 388.

Coloniis epiphyllis 0.5–1 mm. diam. Ascstromatis superficialibus, nigris, elongatis, 1 mm. longis, 0.1 mm. latis. Mycelio  $3\ \mu$  diam., crasso cum pariete, remote septatis, anastomososo-reticulatis. Hyphopodiis paucis in coloniis senibus, simplicibus, ovatis, globosis vel bilobatis,  $5\text{--}6\ \mu$  latis,  $3\text{--}6\ \mu$  altis; ascis globosis,  $28\text{--}34 \times 15.5\text{--}18.5\ \mu$ , octosporis, paraphysatis; sporidiis fuscis, 1-septatis,  $14\text{--}16 \times 6.5\text{--}8.6\ \mu$  ad septum constrictis, obtusis, cellula superiore latiore.

## Family MICROPELTACEAE

**Parapeltella portoricensis** (Speg.) comb. nov.

*Micropeltidium portoricense* Speg., Bol. Acad. Nac. Cienc. Córdoba 26: 351. 1923.

On *undetermined* host.

VENEZUELA, Carabobo, Las Trincheras, M. F. Barrus and A. S. Müller, Feb. 24, 1940. FV 3858.

This new combination is here proposed in order to clarify a situation already pointed out by Stevens and Manter (23) who gave however no satisfactory solution to it. The genus *Micropeltis* was created by Montague (16: 325) to comprise species with a circular ostiole and hyaline, fusiform, 3-pluriseptate ascospores. Later, Sydow (27: 404) erected the genus *Micropeltella* with characters like *Micropeltis* but with paraphyses. Then, Spegazzini (20: 212) segregated from the genus *Micropeltis* Mont. the genus *Micropeltidium*, characterized by having astomous thyriothecia, stellate dehiscence and paraphysate asci. The genus

*Micropeltella* Syd. was likewise divided into *Micropeltella* Syd. with thyriothecia having circular ostioles perforated from the beginning and aparaphysate asci, and *Parapeltella* Speg. with astomous thyriothecia, aparaphysate asci and clavate ascospores.

In a later paper, the same author (21: 350) describes again the genus *Micropeltidium*, this time with cylindrical or fusoid ascospores, astomous thyriothecia and aparaphysate asci, and erects 2 species, *Micropeltidium monense* and *M. portoricense*, both species with clavate spores.

The second species, *M. portoricense*, is then placed by Spegazzini (loc. cit: 352) in a section of *Micropeltidium*, which he proposes to name *Metapeltella*, characterized by clavate spores, astomous thyriothecia and aparaphysate asci. It is thus clear that the two species, since they have clavate spores, should be transferred to *Metapeltella*, but a comparison of the genera *Parapeltella* and *Metapeltella*, discloses the fact that there is no difference between them, and consequently *Parapeltella* being first created should stand; the two species must pass to *Parapeltella*, and the genus *Metapeltella* should be discarded.

The Venezuelan material has mostly epiphyllous, blackish, circular, astomous thyriothecia, 500–600  $\mu$  in diameter, with a hyaline border about 60  $\mu$  wide; dehiscence is stellate. The asci are obclavate, 6–8 spored with rounded apices, 47–62  $\times$  19–25  $\mu$ . The ascospores are clavate, 5–6 septate, slightly constricted at the septa, 28–34  $\times$  5.5–6.5  $\mu$ . Paraphysoids are abundant.

SACCARDINULA USTERIANA Speg., Rev. Mus. La Plata 15: 30. 1908.

On *undetermined* host.

VENEZUELA, Carabobo, Las Trincheras. M. F. Barrus and A. S. Müller, Feb. 24, 1940. FV 3858.

The type has not been seen but the present specimen presents very slight differences from the original description. The thyriothecia are epiphyllous, 460–620  $\mu$  in diameter, circular with fimbriate margins, and scattered over the leaf surface. They are brown at the center and cellulose-hyaline at the borders, the covering being plechtenchymatous. A pseudoostiolum is present. The

asci are various in shape and size, globose or broadly ovate with rounded, heavily thickened apex and walls, short stipitate,  $47-56 \times 25-35 \mu$ , paraphysate, 4-8 spored, visible through the perithecial covering and located at the center of the thyriothecium; ascospores conglobate, cylindrical with tip-cells bluntly rounded, straight or curved, usually with 7 cross-septa and 3-5 longitudinal septa, hyaline,  $28-33 \times 6.5-9 \mu$ , at first mucose-tunicate, then naked, scarcely constricted at septa or not at all.

The thyriothecia when young present a marginal band of delicate, hyaline mycelium, densely reticulated and having a fimbriate margin, whereas the older ones have simple or entire margins. No ostiolum is found but at the top there is a visible, circular, transparent area which remains even in the larger ascomata. Whether or not this area be lysigenous was not observed. In a cross section of the thyriothecium it is seen that the asci are enclosed in an apical cavity walled-off by a layer of densely interwoven hyaline or brownish hyphae. The shield-cover in the young or almost mature thyriothecia are plechtenchymic in nature but as the thyriothecia grows older the hyphae lose their identity and the structure resembles that of the shield cover of the *Dyctiopeltinae*, though somewhat coarser.

#### Order DOTHIDEALES

This interesting group of fungi has received preferential attention from Chardón, who has reported a score of new species in several papers (4-5-6-7-8) based on collections made by himself and Toro in Colombia and in Venezuela. A few species were also reported a couple of years ago by the writer (12) but in relation to the total number of species that must be represented in both countries, the number of already reported species is still very small. As a matter of fact, a large number of species has been collected, which will be the subject of further studies.

The treatment and relationships of this group have been the subject of controversies among mycologists, based principally on the interpretation that each of them gives to the development of the stroma in this and related orders. Recently, light has been thrown on the question by Miller (14) in one of the most important contributions on the subject. The artificiality of the



generic characters on which Theissen and Sydow based their well known monograph of the order (31) has also been the cause of the reluctance of many authors to accept it. It seems, however, to be the most modern and extensive treatment, and has been regularly followed by some leaders in the group. The author also follows the treatment but transfers the genus *Bagnisiopsis* to the *Pseudo-sphaeriales*, under the authority of Miller and Burton (15) who have recently made a critical study of the genus, especially with regard to the species occurring in the *Melastomaceae*.

Family PHYLLACHORACEAE

CATACAUMA INGAE Chardón, Jour. Dept. Agric. Porto Rico 13: 7. 1929.

On *Inga* (*edulis* Mart?).

COLOMBIA, Cundinamarca, Fusagasugá, L. M. Murillo, May 12, 1940. FC 1674; Med. 421.

This specimen differs from the original description in having hypophyllous instead of epiphyllous stromata although the portion of compact stromatic tissue situated just above the locule, is also visible on the upper surface of the leaf. The size of the ascospores is a little larger than described for the type, ranging from  $26-30 \times 4.5-5 \mu$ ; oil drops are rather frequent in the ascospores.

*Phyllachora Abutilonis* sp. nov.

Spots slightly exceeding the stromata. Stromata minute, amphigenous, black, shiny, convex on both sides, circular, 0.2–0.5 mm. diameter, more noticeable on the upper surface of the leaf, mostly unilocular. Locules globose or elliptical, completely immersed in the mesophyll and surrounded by stromatic tissue,  $170-280 \times 240-370 \mu$ ; asci clavate or cylindrico-clavate,  $75-90 \times 10.5-12 \mu$ , 8-spored, with spores biseriata in the main body of the ascus, or uniseriate; ascospores 1 celled, ovoid,  $11-12 \times 6.5-7 \mu$ , hyaline. Paraphyses present.

On *Abutilon* sp.

COLOMBIA, Antioquia, Sabaneta near Medellín, 1650 m., Garcés, Sept. 7, 1942. FC 1684; Med. 431.

Maculis stromata leniter excedentibus. Stromatis minutis, amphigenis, nigris, circularibus, 0.2–0.5 mm. diam., plerumque unilocularibus. Loculis

globosis vel ellipsoideis in mesophyllo immersis,  $170-280 \times 240-370 \mu$ . Ascis clavatis vel cylindrico-clavatis, 8-sporatis,  $75-90 \times 10.5-12 \mu$ ; sporidiis ovoideis,  $11-12 \times 6.5-7.5 \mu$ , hyalinis. Paraphysibus praesentibus.

No species of *Phyllachora* has been heretofore described on *Abutilon*; *Phyllachora minuta* P. Henn., occurring on *Malvaceae* has smaller spores and the stromatal characters are different.

PHYLLACHORA BOTELOUAE Rehm, Hedwigia 36: 373. 1897.

On *Chloris radiata* (L) Schw.

COLOMBIA, Valle, Palmira Agric. Exp. Sta., 1000 m., Garcés, Jan. 14, 1941. FC 1673; Med. 420.

***Phyllachora clavata* sp. nov.**

Spots amphigenous very conspicuous, irregular or circular in shape with a yellow band usually 2 mm. wide bordering the stromata; stromata amphigenous, black, shiny, slightly raised on the lower, less so on the upper side of the leaf, circular or irregular, 1-7 mm. in diameter, showing many tiny black, raised points. Loculi several in the stroma, lenticular, subglobose or deformed through lateral pressure, immersed in the mesophyll  $430-530 \times 250-450 \mu$ . Clypeus initiated beneath the epidermis and there of light color; dark stromatic tissue around the locules; asci elongate, subclavate or sub-cylindrical with truncate apices, 8-spored,  $110-140 \times 15-18 \mu$ ; ascospores biserial or inordinate, hyaline, elongate, straight or slightly curved, with one blunt end, the other acute,  $39-45 \times 3-6 \mu$ . Paraphyses filiform, abundant.

On *Myrica* sp.

COLOMBIA, Antioquia, Alto "Las Palmas," 2700 m., Hno. Daniel, Feb. 14, 1942. FC 1859.

Maculis amphigenis subflavis, valde conspicuis, irregularibus vel circularibus, 2 mm. latis iuxta stromata. Stromatis amphigenis nigris, nitidis, circularibus vel angulosis, 1-7 mm. diam. Loculis pluribus, lenticularibus, subglobosis vel deformatis, in mesophyllo immersis,  $430-530 \times 250-450 \mu$ . Ascis elongatis, subclavatis vel subcylindratis cum truncato apice, 8-sporatis,  $110-140 \times 15-18 \mu$ ; sporidiis distichis vel inordinatis hyalinis, elongatis, rectis vel leniter curvatis, clavulatis, altero apice obtuso, altero apice acuto,  $39-45 \times 5-6 \mu$ . Paraphysibus filiformibus abundantibus.

The shape and the size of the ascospores as well as the conspicuous appearance of the yellow band around the stromata distinguishes this species from any other described on *Myrtaceae*.

PHYLLACHORA DIOCLEAE P. Henn., Hedgwigia 43: 252. 1904.

On *Dioclea sericea* H.B.K.

COLOMBIA, Valle, Highway Cali-Al Mar, K. 3, 1150 m., Garcés, Nov. 17, 1940. FC 1857.

The type was not seen; comparisons were made with *P. Diocleae* P. Henn. on *Dioclea reflexa* Hook from Costa Rica (Stevens' 876, CUPP 14676); while the characters of the asci and ascospores closely agree, the appearance of the stromata in the Colombian material is very different. They are black, flattened and forming almost concentric, broken rings, about 1-2 mm. wide.

**Phyllachora gynericola** sp. nov.

Stromata amphigenous, black, isolated, ellipsoid or circular, 1-3 mm. long  $\times$  1-1.5 mm. wide, bordered by a narrow discolored zone, and often in the center of oval, large grayish-brown or ashy spots. Loculi 3-5 in each stroma and immersed in the mesophyll, globose or irregular in shape and completely surrounded by a black, heavy stroma. Asci clavate or saccate, paraphysate, 8-spored, pedicellate when young, with a spore body of  $115-140 \times 30-36 \mu$ , with spores distichous or inordinate; ascospores hyaline, simple, elliptic-elongate when young and finally angular or deformed, usually with one blunt end and the other pointed,  $30-33 \times 11-12.5 \mu$ . Paraphyses filiform, abundant.

On *Gynerium saccharoides* H.B.K.

COLOMBIA, Antioquia, Sabaneta, Medellín, 1650 m., Garcés, Sept. 7, 1942. FC 1677; Med. 424.

Stromatis amphigenis nigris, isolatis, ellipsoideis vel circularibus, 1-3 mm.  $\times$  1-1.5 mm. diam. zonula angusta et decolorata cinctis et saepe in mediis maculis ovatis et magnis. Loculis 3-5 in utraque stroma, in mesophyllo immersis, globosis vel irregularibus. Asci clavatis vel sacciformibus, paraphysatis, 8-sporatis, sporato corpore  $115-140 \times 30-36 \mu$ ; sporidiis distichis vel inordinatis, hyalinis, elliptico-elongatis immaturis, deformatis maturis,  $30-33 \times 11-12.5 \mu$ . Paraphysibus filiformibus abundantibus.

Apparently, this is the first report of a species of *Phyllachora* on *Gynerium*. This is a conspicuous and beautiful *Phyllachora* commonly found all through the Medellín Valley.

PHYLLACHORA NOTABILIS Petrak & Cif., Ann. Myc. 28: 396. 1930.

On *Stigmatophyllon* sp.

COLOMBIA, Valle, Highway Cali-Al Mar, K. 22, 2200 m., Garcés, Nov. 17, 1940. FC 1856.

Although our specimen differs slightly from the original description in that it shows epiphyllous or hypophyllous stromata, in most of the other characters it agrees very well. The other species of *Phyllachora* on *Stigmatophyllon*, *P. inconspicua* Chardón, is quite different as shown on close examination of FPR 901.

PHYLLACHORA OXYSPORA Starb., Bih. Sv. Vet-Akad. Handl. 25: 45. 1900.

On *Sorghastrum stipoides* (H.B.K.) Nash.

COLOMBIA, Antioquia, Normal de Varones, Medellín, 1750 m., Garcés et al., Dec. 3, 1941. FC 1860.

PHYLLACHORA SPHAEROSPERMA Winter, Hedwigia 23: 170. 1884.

On *Cenchrus Brownii* Roem & Schult.

COLOMBIA, Valle, Palmira Agric. Exp. Sta., 1000 m., Garcés, Jan. 14, 1941. FC 1672; Med. 419.

This specimen was compared with *P. sphaerosperma* on *Cenchrus equinatus* (FPR 928) and shows no difference from the Porto Rican material. The ascospores are globose, 8.5–9  $\mu$  in diameter and hyaline. No darker spores were found which would lead to the transfer of the species to the genus *Sphaerodothis*, as suggested by Stevens and Moore (Illinois Biol. Monog. 11: 43. 1927).

PHYLLACHORA VISMIAE Stevens, Illinois Biol. Monog. 11: 41. 1927.

On *Vismia latifolia* Choisy.

COLOMBIA, Meta, near Villavicencio, 498 m., E. Orjuela, Sept. 12, 1941. FC 1858; Bog. 839.

### ***Sphaerodothis Meriania* sp. nov.**

Spots brown, conspicuous, amphigenous, 3–7 mm. diam. Stromata hypophyllous, black, not shining, convex and circular, 1–1.5 mm. in diam., mostly diloculate. Locules globose, very large, 460–620  $\times$  500–770  $\mu$ , immersed in the mesophyll and surrounded on all sides by black stromatic tissue; asci cylindric-saccate, 8-spored, 230–240  $\times$  25–37  $\mu$ , with spores uniseriate, biseriate or inordinate; ascospores elliptical with blunt ends, continuous, at first orange-

yellow in color, finally brown,  $25-31 \times 16-19 \mu$ . Paraphyses filiform, abundant.

On *Meriania nobilis* Triana.

COLOMBIA, Antioquia, Rionegro, 2400 m., Garcés et al., Oct. 1942.  
FC 1802; Med. 548.

Maculis amphigenis conspicuis, 3-7 mm. diam. Stromatis hypophyllis nigris, circularibus, 1-1.6 mm. diam., biloculatis. Loculis globosis,  $460-620 \times 500-770 \mu$  diam., in mesophyllo immersis et ab stromatico textu circumdatis. Ascis cylindrico-saccatis, 8-sporatis,  $230-240 \times 25-37 \mu$ ; sporidiis monostichis, distichis vel irregulariter dispositis,  $25-31 \times 16-19 \mu$ . Paraphysibus filiformibus abundantibus.

### Order PSEUDOSPHERIALES

BAGNISIOPSIS AMADELPHA (Syd.) Petrak, Hedwigia 68: 280. 1928.

On *Miconia caudata* DC.

COLOMBIA, Antioquia, Robledo, near Medellín, 1750 m., Garcés, July 1942. FC 1652; Med. 399.

On *Miconia granulosa* (Bonp.) Naud., Robledo, 1750 m., Garcés, June 15, 1941. FC 1370; Bog. 115.

According to Miller and Burton (15) this species was reported by Chardón (6) under the name *Dothidina peribebuensis*; a new host and a new locality are here recorded.

*Bagnisiopsis miconicola* sp. nov.

Stromata hypophyllous, verrucose with setae-like processes, black, 0.5-1 mm. diam., occurring in groups of 4 to 5, causing small, dark spots on the upper surface of the leaf. Locules simple, large, globose,  $320 \times 290-600 \times 500 \mu$ ; asci cylindrical, 8-sporèd, paraphysate, long stipitate, with rounded apex,  $230-260 \times 18.5-19.5 \mu$ ; ascospores monostichous, hyaline, with a slight greenish-blue hue, thick-walled, elliptical with both ends acute,  $18-21 \times 9-10 \mu$ . Paraphyses filiform, abundant.

On *Miconia squamulosa* Triana.

COLOMBIA, Cundinamarca, Hills above Usaquén, 3000 m., Garcés et al., Oct. 3, 1939. FC 1861.

Stromatis hypophyllis 0.5-1 mm. diam. nigris. Loculis simplicibus, globosis,  $320 \times 290-600 \times 500 \mu$ . Ascis cylindræis, 8-sporatis, paraphysatis, longe stipitatis, rotundato apice,  $230-260 \times 18.5-19.5 \mu$ . Sporidiis monostichiis, hyalinis colore subviridi, densis parietibus, ellipsoideis,  $18-21 \times 9-10 \mu$ . Paraphysibus filiformibus abundantibus.

According to Miller and Burton (15: 315) of the species of *Bagnisiopsis* on the *Melastomaceae* with dark stromata only two *B. Toledo* Chardón, and *B. amadelpha* (Syd.) Petrak have setae-like processes. The present specimen differs from both of these in the size of the loculi, asci and spores. A comparison with the type of *B. Toledo* and with *B. amadelpha* FV 443 leads to the conclusion that they are different from the Colombian species.

*BAGNISIOPSIS PERIBEBUYENSIS* (Speg.) Theiss. & Syd., Ann. Myc. 13: 292. 1915.

On *Miconia versicolor* Naud.

COLOMBIA, Cauca, road between Popayán and Puracé, 2600 m., E. Perez et al., July 10, 1939. FC 1676; Med. 423.

Chardón (6) reports *Dothidina peribebuyensis* (Syn. = *Bagnisiopsis peribebuyensis* (Speg.) Theiss.) on *Miconia* sp. but according to Miller and Burton (15: 329) Chardón's specimen is *B. amadelpha* (Syd.) Petrak.

*MAIREELLA ANDINA* (Chardón) Petrak, Ann. Myc. 38: 210. 1940.

On *Mikania Ruiziana* Poepp.

COLOMBIA, Cundinamarca, "La Cadena," road Bogotá-Girardot, 2850 m., R. Obregón et al., June 4, 1941. FC 1469; Bog. 1214.

This collection was compared with Chardón's FC 447b previously described under *Uleodothis andina* Chardón (6). Chardón's material also has brown spores. Our specimen agrees in all details with it, except in that only epiphyllous stromata are present. Jenkins (13: 397) considers this species might be similar to *Achorella guianensis* Stevens, which she transfers to *Maireella guianensis*. A comparison of Stevens' species (CUPP 16790) with Chardón's material FC 447b shows a close similarity between them except for the size and shape of the asci which are shorter and more cylindrical in *Maireella guianensis*, while in *Maireella andina* they are clavate. It is however highly probable that a critical comparison of both species will show that Jenkin's assumption is correct.

A new locality is here recorded for the species.

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## A NEW DISCOMYCETE FROM THE OLYMPIC NATIONAL FOREST<sup>1</sup>

BESSIE B. KANOUSE

Among the numerous discomycetes that were obtained by Dr. A. H. Smith in the Olympic National Forest, Washington, is one for which the writer can find no description. It is described here in the family Helotiaceae, tribe Ciborideae. It was collected on decayed leaves of *Alnus* sp. June 3, 1939.

### *Pseudociboria* gen. nov.

Apothecia parva, brevissime stipitata, sine stromate, ceraceo-coriacea, brunnea aut nigra, plane expansa, minute crenulato margine, extrinsecus striata; hypothecia prosenchymatica, nongelatinosa, asci cylindranei, 8 sporis; ascosporae hyalinae, ellipsoideae, unicellulares; aliae paraphyses hyalinae, nonseptatae, 1  $\mu$  diam., aliae paraphyses atro-brunnea, nonseptatae 4  $\mu$  diam.

Type species *P. umbrina*.

Apothecia small, stipitate to substipitate, lacking a stroma, waxy coriaceous, dark brown to blackish brown, disc plane, marginate, externally striate; hypothecium prosenchymataceous, nongelatinous; asci cylindrical clavate, 8-spored, spores ellipsoid to subovoid, 1-celled, hyaline; paraphyses of two kinds, one kind filamentous, hyaline, 1  $\mu$  in diameter, the second kind cylindrical, dark brown, 4  $\mu$  in diameter, epithecium lacking.

### *Pseudociboria umbrina* sp. nov.

Apothecia 1-1.5 mm. lata, brunnea, stipitata, sine stromate, extrinsecus striata, plana, crenulato margine, non-gelatinosa; hypothecia prosenchymatica; stipites brunnei, .75-1 mm. alti, longitudinaliter striati; asci cylindranei, 55-70  $\times$  6-7  $\mu$ , 8 sporis, J-; spores ellipsoideae vel subovoidae, 5.5-7  $\times$  3.5-4  $\mu$ , unicellulares, hyalinae; aliae paraphyses hyalinae, nonseptatae filiformes 1  $\mu$  diam., aliae paraphyses brunneae, nonseptatae, filiformes, 4  $\mu$  diam.

In emortis foliis Alni. Specimen typicum legit prope Lake Crescent. Olympic National Forest, Washington, June 3, 1939. A. H. Smith 18933. Herb. Univ. Mich. conservatum.

Apothecia foliicolous, stipitate, arising from leaf blades or veins, without stroma, stipe 1 mm. long, .5 mm. wide, expanding rather

<sup>1</sup> Papers from the Herbarium of the University of Michigan.

abruptly into the disc, externally longitudinally striate, dark brown to black-brown; disc plane remaining expanded on drying, .75–1 mm. in diameter, concolorous with the stipe, margin minutely crenulate with the free ends of the bundles of the excipular cells, apothecium entirely prosenchymateous, nongelatinous, cell walls light brown, contents hyaline, the point of the inverted cone-shaped central core extending into the top of the stipe, excipular cells forming a thick, more or less firm layer, cell walls and contents colored brown, outer excipular cells decorated with longitudinal striations or irregular netting of dark brown cells; hymenium composed of asci and 2 types of paraphyses, asci cylindrical-clavate,  $55\text{--}70 \times 6\text{--}7 \mu$ , 8-spored; spores typically obliquely uniseriate in the asci; spores ellipsoid to subovoid,  $5.5\text{--}7 \times 3.5\text{--}4 \mu$ , hyaline, 1-celled; hyaline paraphyses filiform,  $1 \mu$  in diameter, nonseptate, not forming an epithecium, colored paraphyses narrowly cylindrical,  $4\text{--}4.5 \mu$  in diameter, filled completely with a dark brown coloring matter, apices rounded, nonseptate, no forming an epithecium. Apothecium not stained blue with iodine. Dark brown cell contents soluble in KOH, solution becomes stringly and quickly stained a bright pinkish red.

Conidial stage unknown.

On decayed leaves of *Alnus* sp., Lake Crescent Olympic National Forest, Washington, June 3, 1939. A. H. Smith 18933. Type deposited in the Herbarium of the University of Michigan.

The morphological characteristics exhibited by this fungus require the establishment of a new genus. It belongs in the family Helotiaceae, tribe Ciborideae. Because of the absence of a sclerotium it can not be placed in the genus *Sclerotinia*. White<sup>2</sup> has delimited the genus *Ciboria* as follows: "true *Ciborias* . . . are associated in nearly all cases with inflorescences; they apparently rarely if ever occur on wood, stems or leaves. They completely stromatize the floral structure in the form of a mummy." Our fungus has no stroma and it is foliicolous. With respect to the genus *Rutstroemia*, White (l.c.) names several fundamental characters that he says distinguish the genus. Among them are: presence of stroma; production of spermatia; apothecia having a middle gelatinized zone in the ectal excipulum; ascospores becoming one to several septate at maturity; production of apothecia in

<sup>2</sup> White, W. Lawrence. A monograph of the genus *Rutstroemia* (Discomycetes). *Lloydia* 4: 153–240. 1941.

late summer and early fall. On all of these counts our fungus differs from the genus *Rutstroemia*. An outstanding difference between our fungus and the genera mentioned above, is the presence, in *P. umbrina*, of hyaline and of colored paraphyses. The occurrence of two kinds of paraphyses is, as far as the writer is aware, a character not known in any other discomycete. Colored paraphyses are found in species of *Rutstroemia* and *Ciboria*. But in all cases they are the only type produced and the coloring matter is restricted to the upper portion of the paraphyses and is usually a light or golden brown color. In *P. umbrina* the colored paraphyses are produced in addition to the colorless ones. The pigmentation is dark brown and is distributed throughout the entire length of the filaments. Sections mounted in water show that the coloring matter is not water soluble. It is broken up into short sections resembling beads. The color is a dark brown. Sections mounted in dilute KOH show a striking chemical reaction which is a good specific character. In KOH solution the coloring matter is immediately dissolved producing a bright pinkish red color in the solution. The pigment in the colored paraphyses and in the colored excipular cells reacts the same. The heretofore dark cells quickly become pale pinkish in color, with the tint evenly distributed within the cells. From sections so treated it can be seen that no cross walls are present in the paraphyses that were formerly brown. Iodine solution does not stain any portion of the apothecium blue. Both types of paraphyses arise from the lower part of the hymenial layer. This portion is very compact and it is difficult to determine, even in section, the actual origins of either asci or paraphyses. However, the colored contents of the larger paraphyses makes it possible to see that they arise from the same hymenial tissue as the asci and hyaline paraphyses. The colored paraphyses are not at all like setae. The tips are rounded and the walls are thin.

Studies made from cross sections of the fungus show an inverted cone of hypothecial tissue that is entirely prosenchymateous. The cell walls are light brown in color and the contents are nearly hyaline. The cell walls are thin and the hyphae are intricately interwoven. This core of tissue connects directly with the excipular layer, and above with the hymenium. There is no gelatinous layer.

In microscopical mounts the hymenium can be forced out leaving the excipular shell nearly intact. The netted appearance of the outermost layer of excipular cells can then be plainly seen. This net becomes radially striate near the base of the cups and the striations extend downward longitudinally the length of the stipe. Upward the strands form the shallow crenulate margin. The free ends of these hyphae are arranged in small bundles of from 10-15 ends in each bundle. The tips of these hyphae are rounded. The scallops formed by them are not tooth-like nor do they form a fringe.

The asci and spores are typically those of *Ciboria* spp. The lack of a stromatic condition and the presence of the two types of paraphyses make it necessary to erect a distinct genus for the fungus.

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## A NEW RUST OF ORCHIDS

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(WITH 8 FIGURES)

Among the interesting genera that have been assigned by Dietel (2) to the tribe Ravenelieae of the Pucciniaceae, belongs the genus *Sphenospora* which occurs in Africa, but primarily in the American tropics. The genus occurs on such widely separated host genera as *Dioscorea*, *Smilax* and *Copaifera*, and to these must now be added *Epidendrum* of the Orchidaceae. The material about to be described was received from Dr. A. G. Keyorkian through the kindness of Prof. W. H. Weston, Jr., who turned it over to the writer for study and determination. It is indeed a great pleasure to the writer to dedicate this species to Dr. Kevorkian, not only because of his interest in the orchids, but more especially because of his many collections of interesting fungi of the tropics.

### *Sphenospora Kevorkianii* sp. nov. (FIG. 1-8)

Pycnia et aecia ignota. Uredosori hypophylli, subepidermales, primum tecti, hemisphaerici, demum erumpentes subcupulatique, aparaphysati; uredosporae ellipsoideae, obovatae vel subsphaericae,  $28-33 \times 18-26.5$ , membrana flavida,  $1.5-3.3 \mu$  cr., echinulata, poris germinalibus obscuris, 1 vel (?) 2, aequatorialibus; teleutosori hypophylli in maculis irregulariter vel circulariter instructi, atro-fusci vel atrii, usque ad 1 mm. diametro; teleutosporae obovoideae vel ellipsoideae parietibus hyalinis tenuibusque praeditae,  $23-28 \times 13-16.5 \mu$ , primum unicellulatae deinde longitudinaliter 1-septatae, cellula utraque basidium unicum sessile (1)-2-(3) septatum et  $\pm 33 \times 6.5 \mu$  gerens, pediculi teleutosporarum hyalini, robusti,  $41-66 \times 6.5-8.3 \mu$  a cellula magna oriente; paraphyses numerosae, clavatae vel cylindricae, rectae vel conspicue recurvatae, primum dense luteo pigmentatae, parietibus tenuibus praeditae,  $100-116 \times 8-10.5 \mu$ .

**Pycnia** and **aecia** unknown. **Uredosorus** hypophyllous, subepidermal, at first covered and hemispherical, then erumpent and subcupulate, aparaphysate. **Uredospores** ovoid, ellipsoid or subspherical,  $28-33 \times 18-26.5 \mu$ , the membrane yellowish, echinulate,  $1.5-3.3 \mu$  thick, the germ-pores obscure, one or possibly two, equa-

<sup>1</sup> Contribution from the Laboratories of Cryptogamic Botany and the Farlow Herbarium, Harvard University, No. 206.

torial. **Teleutosori** hypophyllous in light colored spots, arranged irregularly or loosely clustered in circles, dark brown or black, or lighter colored from the uredospores that remain in the sorus, up to 1 mm. in diameter, subepidermal. **Teleutospores** obovoid or ellipsoid, thin-walled,  $23-28 \times 13-16.5 \mu$ , at first one-celled but becoming longitudinally one-septate, each cell soon bearing a single basidium that is (1-)-2-(3-) septate. **Basidiospores** hyaline or yellowish from the scattered droplets of pigment, globular, ovoid, or irregularly ovoid and mostly apiculate,  $8.2-11.5 \times 6.5-7 \mu$ . **Paraphyses** numerous, clavate or cylindrical, straight or strongly curved or even coiled at or near the apex, thin-walled,  $100-116 \times 8-10.5 \mu$ , at first densely filled with cytoplasm and yellow pigment, then losing their contents and becoming hyaline, either in clusters at the margin of the sorus or singly among the teleutospore pedicels where they arise from the same large basal cells.

On *Epidendrum difforme*, causing considerable damage, Bilwas Karma, Departamento El Capo, Nicaragua, April 6, 1943, A. G. Kevorkian, type.

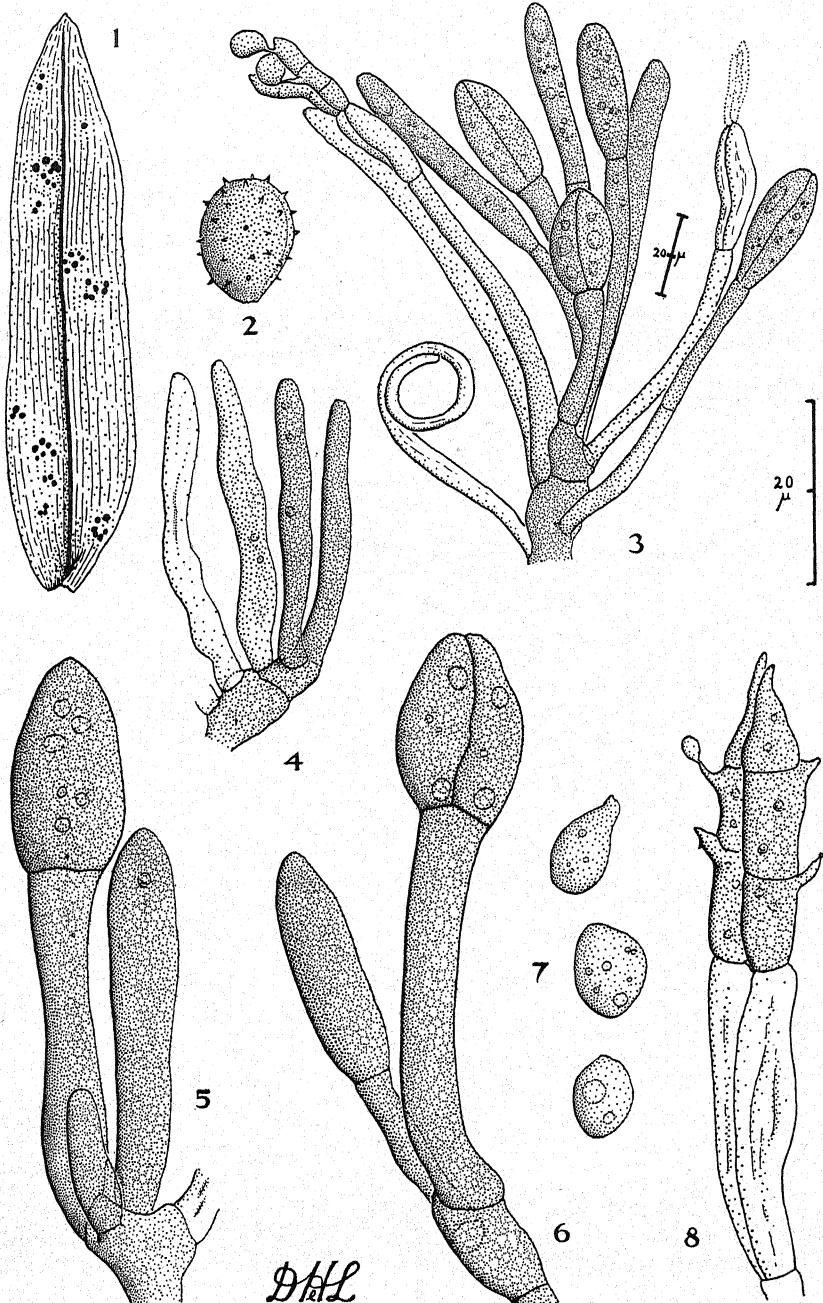
This species is of interest not only because it is parasitic on a member of the Orchidaceae, but also because of its development. The fungus possesses marginal paraphyses in addition to those formed among the teleutospores where they arise from the same large cells that might be termed the teleutospore mother-cells. The teleutospores in the very early stage of development are difficult to distinguish from the paraphyses, but shortly after the future stalk cell (which attains dimensions of  $41-66 \times 6.5-8.3 \mu$ ) has reached a certain size, it begins to enlarge at the apex and then the terminal cell is cut off by the formation of a septum. Shortly thereafter, the terminal cell, having become abruptly enlarged (FIG. 5), becomes longitudinally septate to produce two cells, each of which quickly germinates by the production of a three-celled, rarely a two- or four-celled basidium (FIGS. 6, 7). However, prior to the formation of the basidia from the apices of the cells of the teleutospore, there is a tendency for the two cells to separate near the apex, either as a result of the elongation of the tips prior to basidium formation or else from internal pressure of the spore that pushes them apart. This tendency of the apices of the teleutospore to split recalls Cummins' (1) statement in regard to *Ypsilospora* that "The arrangement of two teliospores upon a common pedicel is similar to that which characterizes the teliospores of

*Sphenospora*, except that here the two spores have no common wall. It should be noted that the teliospores of *Sphenospora Copaiferae* (P. Henn.) Syd. are described (Monogr. Ured. 4: 584. 1924) as '... am Septum meist ziemlich tief eingeschnürt. ...'."

If the splitting of the teleutospore is significant, as has been suggested by Cummins (1), then *Sphenospora* is allied to *Ypsilospora* and this genus is in turn related to *Olivea* and *Chaconia* since these two last named genera may be considered as having arisen from *Ypsilospora* through the aggregation of the free teleutospore pedicels into a dense compound stipe. *Ypsilospora* thus differs from *Olivea* much in the same manner as *Uromycladium* or *Cystomyces* differs from *Ravenelia* excepting that in this latter instance, the stipe cells of *Ravenelia* have remained long and slender instead of becoming short through septation. This difference would not seem unusual when it is considered that two different series of forms have undergone a more or less parallel evolution. If all of these genera were brought together in the Raveneliae, it would then seem logical to include *Maravalia* in the series between *Ypsilospora* and *Chaconia* or *Olivea*, an arrangement that would bring together those forms that appear to have evolved primarily on the Leguminosae and which furthermore have certain morphological characters in common. According to this disposition of the genera, it is suggested that the tribe Oliveae either be dispensed with or reduced to subtribal rank and the Raveneliae be considered a tribe which would then consist of two series, at least, one of which terminates with *Chaconia* or *Olivea* and the other that terminates with *Ravenelia* or a closely related genus. Since this

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FIGS. 1-8: all figures except 1 and 3 are shown at a magnification of  $\times 1150$ , the others are natural size and  $\times 550$  respectively, 1, a relatively heavily infected leaf of *Epidendrum difforme* showing the distribution of the hypophyllous teleutosori; 2, a characteristically shaped uredospore; 3, elements of the hymenium showing the large basal cells from which arise the teleutospores and the cylindrical paraphyses, some of which have lost their contents; 4, enlarged basal cells bearing only paraphyses; 5, at the left a teleutospore initial which has enlarged after becoming separated from the stipe by a septum; 6, a teleutospore initial which has become longitudinally septate; 7, basidiospores which illustrate variation in shape; 8, a teleutospore initial which, having formed two teleutospores, has germinated to form two basidia.





treatment of the Raveneliae is at variance with the ideas of Dietel (2) and Mains (3) and other uredinologists, it will be interesting to see if future cytomorphological studies bear out these conclusions.

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# THE MORPHOLOGY AND TAXONOMY OF *ALTERNARIA CITRI*<sup>1</sup>

DONALD E. BLISS AND H. S. FAWCETT

(WITH 5 FIGURES)

## INTRODUCTION

The original description of *Alternaria Citri* Ellis and Pierce was published in 1902 by Newton B. Pierce (26), in a short article entitled "Black Rot of Oranges." Ten years earlier, this disease had been reported in connection with investigations, presumably by Pierce, in California. In this report (18, p. 238-239), it was stated that the black rot of navel oranges had only recently attracted the attention of orange growers in California, that the distribution of the disease in California was as wide as that of the navel orange itself, that the disease was caused by a new species of fungus belonging to the genus *Macrosporium*, and that it brought about premature ripening and fall of the fruit, with an incidence as high as 10 per cent in some cases.

In 1901, J. H. Reed (27), a prominent citrus grower at Riverside, California, evidently unaware of any previous work on the black rot of oranges, and without referring to any fungus or disease by name, described the black-rot condition and estimated that fruit losses for that season were from 10 to 30 per cent. Apparently replying to Reed's article, Pierce (25) stated that "this disease was thoroughly investigated at Riverside and elsewhere in Southern California by the Department of Agriculture some six or eight years since, and the main facts were given to the public."

In his description of the fungus, Pierce (26) states that single-spore cultures had been made and that "detailed descriptions and illustrations are reserved for publication, together with facts relative to preventive treatment." Unfortunately, these data were apparently not published. As far as can be ascertained, no fungus material studied by Ellis and Pierce is available for examination.

<sup>1</sup> Paper No. 509, University of California Citrus Experiment Station, Riverside, California.

In the absence of such original material, uncertainty has arisen as to the characteristics and limits of *Alternaria Citri*, and as to the identity of related fungi on other fruit crops and on citrus in other parts of the world.

*Alternaria Citri*, or closely allied forms, have been reported in many countries where citrus is grown. In California the fungus is widespread and may be found on all the aerial parts of citrus trees. *A. Citri* has been isolated from desert air at considerable distances from citrus trees (9), and an *Alternaria*, possibly of the same species, has been obtained from air over the ocean 400 miles off the coast of California (28). The following list, showing localities where observations or studies were made, authors, and dates of published reports,<sup>2</sup> emphasizes the wide geographic distribution of *A. Citri*.

**United States—California:** Smith, 1909; Fawcett, 1912, 1915, 1922, 1923, 1925, 1926 (13), 1927, 1929 (14), 1936 (15); Amundsen, 1913 (1); Coit and Hodgson, 1916, 1918 (8), 1919 (9); Bartholomew, 1923 (2), 1926 (3); Barger, 1928, 1933; Horne *et al.*, 1930; Savastano and Fawcett, 1929 (33); Brooks and McColloch, 1936; Fawcett, Klotz, and Nixon, 1936 (17). **Arizona:** Coit, 1908; George, 1922. **Texas:** Fawcett, 1936 (15). **Florida:** Fawcett, 1911, 1912; Stevens, 1919; Burger, 1922, 1923, 1936; Rhoads and De Busk, 1931; Winston, 1937; Ruehle, 1937 (31). **Cuba:** Horne, 1912; Johnston and Bruner, 1918; Bruner, 1921. **Puerto Rico:** Stevenson, 1918. **Argentina:** Blanchard, 1931; Green, 1932; Marchionatto, 1933. **Uruguay:** Acosta, 1931; Fawcett and Bitancourt, 1940. **Paraguay:** Fawcett and Bitancourt, 1940. **Italy:** Sibilis, 1930; Montemartini, 1931; Cocchi, 1931; Fawcett, 1931, 1936. **Portugal** (including **Azores**): Coutinho, 1929; Fawcett, 1931. **Spain:** Kidd and Tomkins, 1928; Fawcett, 1936 (15). **Morocco:** Malençon and Delécluse, 1937. **Greece:** Sarejanni, 1935. **Cyprus:** Natrass, 1932, 1933. **Egypt:** Briton-Jones, 1925; Melchers, 1932; Fawcett, 1936 (15). **Palestine:** Reichert, 1927; Kidd and Tomkins, 1928; Reichert and Perlberger, 1928;

<sup>2</sup> Numbers in parentheses indicate reports of special pathological or mycological interest, included in "Literature Cited" at the end of the present paper.

Fawcett, 1931. **Russia:** Maklakova, 1932; Tzereteli and Tchanturia, 1939. **Southern Rhodesia:** Hopkins, 1930; Bates, 1936, 1937, 1939. **Union of South Africa:** Doidge, 1924, 1929 (11), 1931; Webber, 1925; Evans, 1925, 1929, 1936, 1937; Kidd and West, 1928; Barker, 1928; Doidge and Van der Plank, 1936; Van der Plank *et al.*, 1938; Wager, 1939 (35, 36). **Northern India:** Chaudhuri, 1936. **China:** Yu, 1934; Teng, 1940; Wei, 1940. **Japan:** Fawcett, 1936 (15). **Australia:** Stoward, 1913; Adams, 1923; Kidd and Tomkins, 1928; Young and Read, 1932; Hall, 1938.

Side spot decay of dates, caused by a similar form of *Alternaria*, has been investigated in Arizona by Brown (7), and in California by Fawcett and Klotz (16), and by Turrell, Sinclair, and Bliss (34). A leaf spot of sweet cherry was studied by Rudolph (30), who considered the fungus to be a variety of *Alternaria Citri*.

Although widely distributed in other parts of the world, *Alternaria Citri* appears not to have been reported from tropical countries. The fungus is not mentioned in available reports from the Philippines, Java, Southern India, the middle tropical parts of Africa, Panama, Central America, and the tropical states of South America. In view of the fact that the junior author, in studies in Brazil, found no *Alternaria* in thousands of oranges of different varieties, it is believed that this lack of reports from the tropics may be significant.<sup>3</sup>

The purpose of this paper is to present what the writers consider to be a reasonable concept of *Alternaria Citri* as a species. This concept is based not only on the original description by Ellis and Pierce (26), but also on studies of a considerable number of isolates from navel oranges collected in various localities in southern California, including some of those localities where Pierce obtained his specimens.<sup>4</sup> An emended description of the species has been

<sup>3</sup> Since this was written, an unidentified specimen of *Alternaria* sp. (probably not *A. Citri*) on citrus leaves has been received from Dr. A. A. Bitancourt, Instituto Biologico, São Paulo, Brazil. He states that *Alternaria* has been found only rarely on *Citrus* in Brazil.

<sup>4</sup> Pierce was Special Agent in California, U. S. Department of Agriculture, Division of Vegetable Pathology, in charge of the Pacific Coast Laboratory of the Bureau of Plant Industry, Santa Ana, California. He mentioned specifically (25) that the black rot of oranges was investigated especially at Riverside.

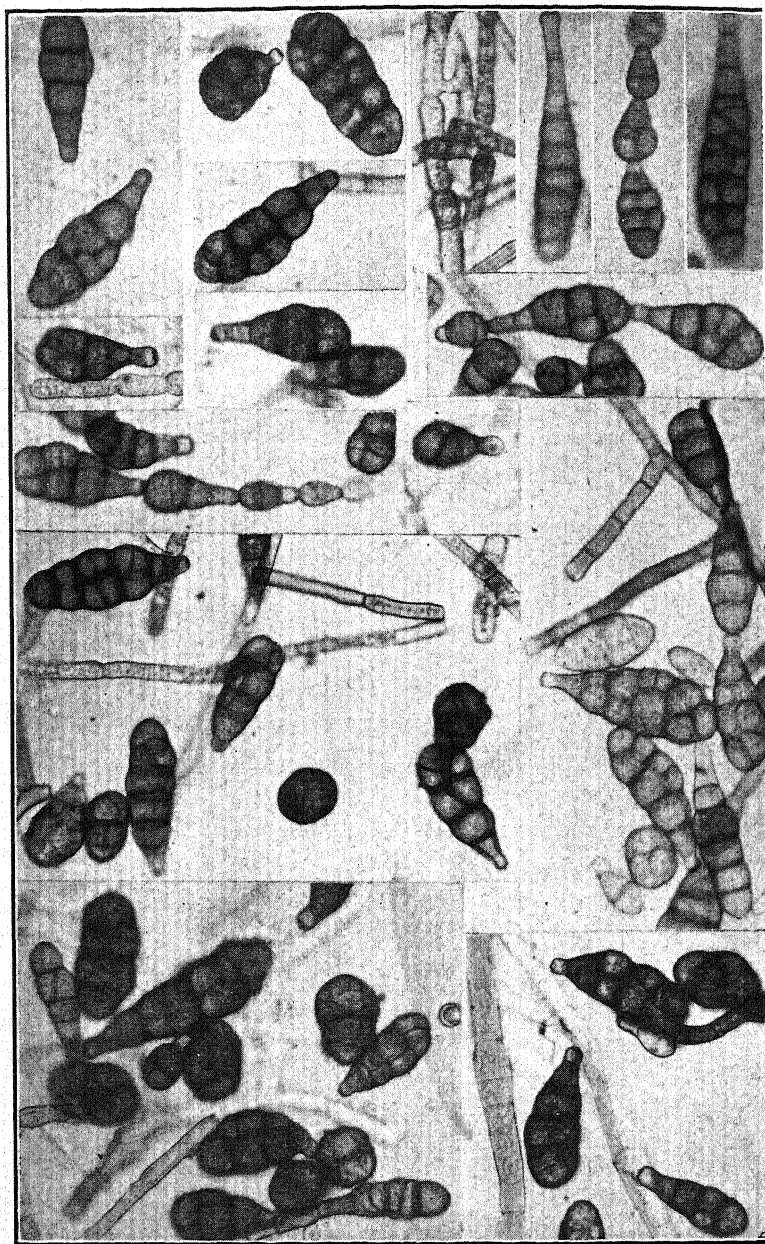


FIG. 1. *Alternaria Citri* Ellis and Pierce. Type culture no. 2077 on Czapek's agar; incubated 8 days at 26° C. ( $\times 593$ .)

prepared from a neotype, specimens of which have been deposited in several herbaria. New evidence is presented on the morphology and taxonomy of *Alternaria Citri*, based on a statistical study of 26 isolates from fruit of Washington Navel orange, Deglet Noor date palm, and Holguin guava. The taxonomic relation of *A. Citri* to certain other short-beaked forms of the genus is also discussed.

#### METHODS

During January, February, and March, 1943, isolates of *Alternaria* and other fungi were taken from fruit of the Washington Navel orange (*Citrus sinensis* [L.] Osbeck), the Deglet Noor date palm (*Phoenix dactylifera* L.), and the Holguin guava (*Psidium guajava* L.). Among the isolates of these fungi were certain ones of similar appearance, which were selected for study because they resembled *A. Citri*. Several dissimilar isolates, from date, were reserved for further study.

Isolates from orange, nos. 2060, 2061, 2062, 2067, 2068, 2069, 2077, 2078, and 2081, were obtained at the University of California Citrus Experiment Station, Riverside, California; nos. 2063, 2064, and 2065, at North Whittier Heights, California; nos. 2070 and 2071, at Claremont, California; nos. 2072 and 2073, at Azusa, California; nos. 2074, 2075, and 2076, at Charter Oak, California; and nos. 2079 and 2080, at Altadena, California. Isolates from date, nos. B-709, B-714, B-717, and B-719, were obtained at Indio, California. The isolate from guava, no. B-740,<sup>5</sup> was obtained at Riverside, California. Spore measurements from these 26 isolates, taken between February 11 and May 21, 1943, form the basis of the present study.

The isolates of *Alternaria* were grown in petri dishes at 26° C., on 2 per cent Czapek's agar<sup>6</sup> (pH 5.12), 2 per cent corn-meal agar<sup>7</sup> (pH 5.8), and on sterile slices of the fruit of Washington Navel orange, Valencia orange, and Eureka lemon. The spores produced on the slices of citrus fruit were so similar that, in sum-

<sup>5</sup> Isolated by W. T. Horne.

<sup>6</sup> Czapek's agar:  $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ , 0.5 gram;  $\text{KH}_2\text{PO}_4$ , 1.0 gram; KCl, 0.5 gram;  $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ , 0.01 gram;  $\text{NaNO}_3$ , 2.0 grams; sucrose, 30 grams; agar, 20 grams; distilled water, 1 liter.

<sup>7</sup> Corn-meal agar: Bacto-Corn-Meal Agar, 22 grams (20 grams agar); distilled water, 1 liter.

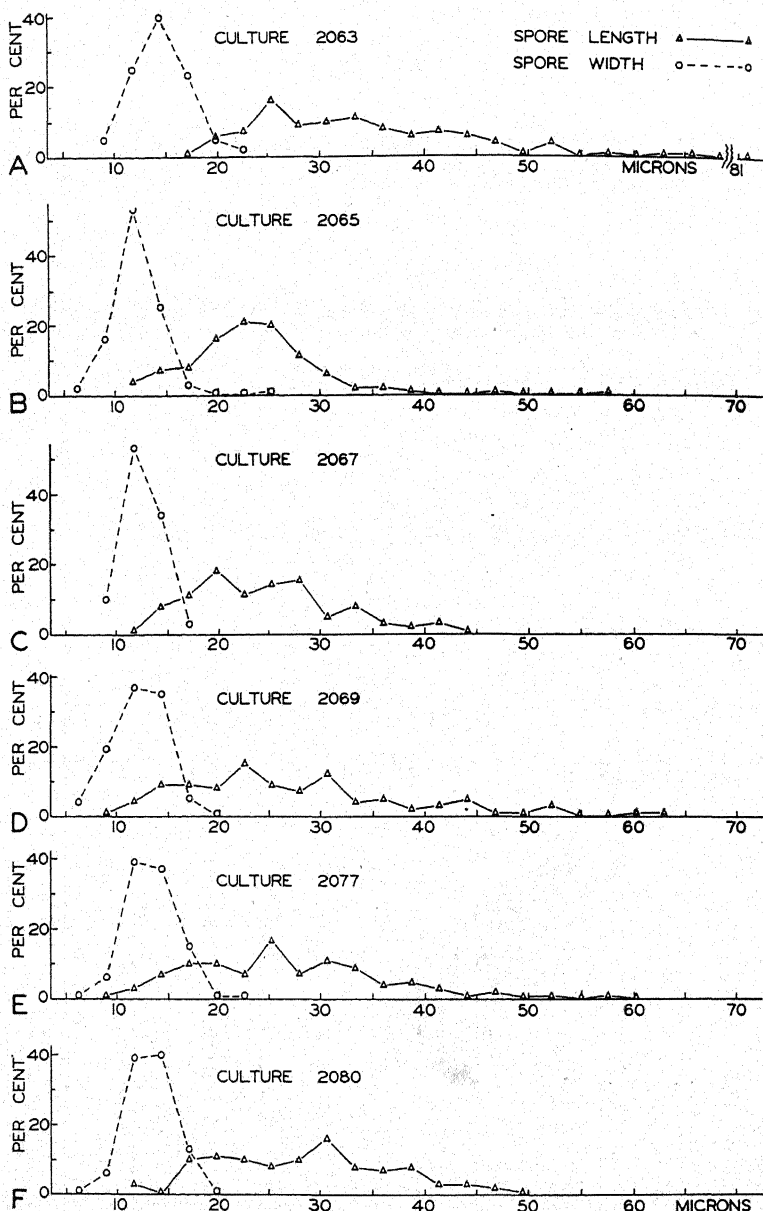


FIG. 2. A-F, curves showing percentage distribution of spores according to length and width, in six single-spore cultures of isolates of *Alternaria Citri* from Washington Navel orange. Each curve represents measurements of 100 spores taken at random.

marizing the morphological data, results from the citrus media were grouped together.

The fungus colony was examined after 7 to 20 days' growth by removing from the petri dish a disk of fungus-covered substrate, 4 mm. in diameter, and mounting it on a microscope slide without cover glass. The habit of growth and the number of spores in the spore chains were observed under low magnification. A small portion of the disk was then mounted in water with a cover glass. The slide was placed on a mechanical stage and moved backward and forward in such a manner as to bring only unexplored areas of the mount into the field of vision. A representative sample, including all the dark-colored, mature spores that entered the field, was used for measurement.<sup>8</sup> Transverse and longitudinal septations in these spores were noted, and spores with and without beaks were recorded on a dual counting device.

Three measurements were made of each spore, namely, the length (including the apical beak, if any), the width, and the length of the apical beak. The apical beaks were relatively short, bluntly pointed structures at the narrow, distal ends of the spores. They were hyaline or less deeply colored than the body of the spore. The length of the beak was measured along the longitudinal axis of the spore, from the apex to the edge of the nearest cell having a dark-brown protoplast (FIG. 5, *A, i*). Spores having either apical or lateral beaks were counted as "beaked spores," but only the apical beaks were included in the spore dimensions. Usually, the terminal spore was the only nonbeaked spore in a chain, although there were sometimes others. Beaked spores typically had a spore scar at the apex. Beaks having two or more spore scars usually had one or more transverse septa (FIG. 5, *A, c, l*).

The septation of recently matured spores was easily determined, but because of the tendency toward secondary cell division and excessive darkening in mature spores, the septation of some of the oldest spores was determined with difficulty. Only the cross walls *between* cells having brown protoplasts were counted as transverse

<sup>8</sup> All measurements were made under a fluorite oil-immersion objective, N. A. 1.32, and a 15 × ocular with eyepiece micrometer on which 1 graduation represented 0.90  $\mu$ . Measurements were read to the closest graduation of the micrometer.



septa. The outer walls of the colored cells in the terminal positions were not counted. In the development of the spore, a median transverse wall marked the first cell division, and other transverse walls were often laid down before the first longitudinal septum appeared. For this reason, the spore was considered to be divided into segments by the transverse septa. Each segment which contained one or more longitudinal walls was counted as having one longitudinal septum.

The number of spores in spore chains was determined principally because of interest in the maximum number, and the number most commonly developed. The relative size of spores in the same chain was also observed.

#### MORPHOLOGY

The percentage distribution of spores of *Alternaria Citri*, according to length (including beak), width, and length of apical beak, when cultured on the different media, is shown in table 1. In this table the scale of measurement is, for convenience, divided into units of  $2.7\ \mu$ , or 3 graduations on the eyepiece micrometer, each.

The wide variation in the length of spores, when grown on Czapek's agar, is remarkable. Although 80 per cent of the spores from isolates from Washington Navel orange measured from  $13.1$  to  $34.6\ \mu$  in length (a range of  $21.5\ \mu$ ), the other 20 per cent included the remainder of the scale, from  $8.1$  to  $13.0\ \mu$  and from  $34.7$  to  $81.0\ \mu$ . The length encountered most frequently was that between  $23.9$  and  $26.5\ \mu$ , although only 14 per cent of the spore population was included in this class. In isolates from date, on Czapek's agar, 82.7 per cent of the spores measured between  $13.1$  and  $34.6\ \mu$  in length, and the extremes were  $9.9$  and  $57.6\ \mu$ , respectively. In this case, the length encountered most frequently was that between  $21.2$  and  $23.8\ \mu$ , including only 12.8 per cent of the spore population—a group only slightly larger than five others. The width of spores grown on Czapek's agar was considerably more uniform than the length. In isolates from orange, 89.3 per cent of the spores were  $7.7$  to  $15.7\ \mu$  wide, while in isolates from date, 94.8 per cent were in this range. Spores with long beaks were found occasionally, but at least 90 per cent of spores from the

TABLE 1  
PERCENTAGE DISTRIBUTION OF SPORES OF ALTERNARIA CITRI, ACCORDING TO LENGTH, WIDTH, AND LENGTH OF BEAK, WHEN ISOLATED FROM VARIOUS FRUITS AND CULTURED ON DIFFERENT MEDIA

Culture medium, number of spores measured, and character of measurement	Percentage of spores according to measurement *																							
	0.0 to 2.2 (μ)	2.3 to 4.9 (μ)	5.0 to 7.6 (μ)	7.7 to 10.3 (μ)	10.4 to 13.0 (μ)	13.1 to 15.7 (μ)	15.8 to 18.4 (μ)	18.5 to 21.1 (μ)	21.2 to 23.8 (μ)	23.9 to 26.5 (μ)	26.6 to 29.2 (μ)	29.3 to 31.9 (μ)	32.0 to 34.6 (μ)	34.7 to 37.3 (μ)	37.4 to 40.0 (μ)	40.1 to 42.7 (μ)	42.8 to 45.4 (μ)	45.5 to 48.1 (μ)	48.2 to 50.8 (μ)	50.9 to 53.5 (μ)	53.6 to 56.2 (μ)	56.3 to 58.9 (μ)	59.0 to 61.6 (μ)	61.7 to 64.3 (μ)
Czapek's agar— 1000 spores: Length † Width † Length of beak	0.0 2.2 2.2	2.3 4.9 4.9	5.0 7.6 7.6	7.7 10.3 10.3	10.4 13.0 13.0	13.1 15.7 15.7	15.8 18.4 18.4	18.5 21.1 21.1	21.2 23.8 23.8	23.9 26.5 26.5	26.6 29.2 29.2	29.3 31.9 31.9	32.0 34.6 34.6	34.7 37.3 37.3	37.4 40.0 40.0	40.1 42.7 42.7	42.8 45.4 45.4	45.5 48.1 48.1	48.2 50.8 50.8	50.9 53.5 53.5	53.6 56.2 56.2	56.3 58.9 58.9	59.0 61.6 61.6	61.7 64.3 64.3
Citrus fruit slices— 174 spores: Length † Width † Length of beak	0.0 2.2 2.2	2.3 4.9 4.9	5.0 7.6 7.6	7.7 10.3 10.3	10.4 13.0 13.0	13.1 15.7 15.7	15.8 18.4 18.4	18.5 21.1 21.1	21.2 23.8 23.8	23.9 26.5 26.5	26.6 29.2 29.2	29.3 31.9 31.9	32.0 34.6 34.6	34.7 37.3 37.3	37.4 40.0 40.0	40.1 42.7 42.7	42.8 45.4 45.4	45.5 48.1 48.1	48.2 50.8 50.8	50.9 53.5 53.5	53.6 56.2 56.2	56.3 58.9 58.9	59.0 61.6 61.6	61.7 64.3 64.3
Corn-meal agar— 800 spores: Length † Width † Length of beak	0.0 2.2 2.2	2.3 4.9 4.9	5.0 7.6 7.6	7.7 10.3 10.3	10.4 13.0 13.0	13.1 15.7 15.7	15.8 18.4 18.4	18.5 21.1 21.1	21.2 23.8 23.8	23.9 26.5 26.5	26.6 29.2 29.2	29.3 31.9 31.9	32.0 34.6 34.6	34.7 37.3 37.3	37.4 40.0 40.0	40.1 42.7 42.7	42.8 45.4 45.4	45.5 48.1 48.1	48.2 50.8 50.8	50.9 53.5 53.5	53.6 56.2 56.2	56.3 58.9 58.9	59.0 61.6 61.6	61.7 64.3 64.3
Czapek's agar— 400 spores: Length † Width † Length of beak	0.0 2.2 2.2	2.3 4.9 4.9	5.0 7.6 7.6	7.7 10.3 10.3	10.4 13.0 13.0	13.1 15.7 15.7	15.8 18.4 18.4	18.5 21.1 21.1	21.2 23.8 23.8	23.9 26.5 26.5	26.6 29.2 29.2	29.3 31.9 31.9	32.0 34.6 34.6	34.7 37.3 37.3	37.4 40.0 40.0	40.1 42.7 42.7	42.8 45.4 45.4	45.5 48.1 48.1	48.2 50.8 50.8	50.9 53.5 53.5	53.6 56.2 56.2	56.3 58.9 58.9	59.0 61.6 61.6	61.7 64.3 64.3
Citrus fruit slices— 215 spores: Length † Width † Length of beak	0.0 2.2 2.2	2.3 4.9 4.9	5.0 7.6 7.6	7.7 10.3 10.3	10.4 13.0 13.0	13.1 15.7 15.7	15.8 18.4 18.4	18.5 21.1 21.1	21.2 23.8 23.8	23.9 26.5 26.5	26.6 29.2 29.2	29.3 31.9 31.9	32.0 34.6 34.6	34.7 37.3 37.3	37.4 40.0 40.0	40.1 42.7 42.7	42.8 45.4 45.4	45.5 48.1 48.1	48.2 50.8 50.8	50.9 53.5 53.5	53.6 56.2 56.2	56.3 58.9 58.9	59.0 61.6 61.6	61.7 64.3 64.3
Corn-meal agar— 40 spores: Length † Width † Length of beak	0.0 2.2 2.2	2.3 4.9 4.9	5.0 7.6 7.6	7.7 10.3 10.3	10.4 13.0 13.0	13.1 15.7 15.7	15.8 18.4 18.4	18.5 21.1 21.1	21.2 23.8 23.8	23.9 26.5 26.5	26.6 29.2 29.2	29.3 31.9 31.9	32.0 34.6 34.6	34.7 37.3 37.3	37.4 40.0 40.0	40.1 42.7 42.7	42.8 45.4 45.4	45.5 48.1 48.1	48.2 50.8 50.8	50.9 53.5 53.5	53.6 56.2 56.2	56.3 58.9 58.9	59.0 61.6 61.6	61.7 64.3 64.3

\* For convenience, the scale was divided into units of 2.7 μ, each unit representing three graduations on the eyepiece micrometer. † Including beak, if any.

TABLE 2  
PERCENTAGE DISTRIBUTION OF SPORES OF *ALTERNARIA CITRI*, ACCORDING TO NUMBER OF TRANSVERSE AND LONGITUDINAL SEPTATIONS, WHEN ISOLATED FROM VARIOUS FRUITS AND CULTURED ON DIFFERENT MEDIA

Culture medium	Num-ber of spores exam-ined	Percentage of spores having the given type and number of septa																		
		Transverse											Longitudinal							
		0	1	2	3	4	5	6	7	8	9	10	11	0	1	2	3	4	5	6
		21 isolates from fruit of Washington Navel orange																		
Czapek's agar	1,400	0.4	12.9	17.4	51.5	9.4	4.9	2.3	0.5	0.5	0.1			15.8	22.0	35.9	20.7	5.1	0.5	0.1
Citrus fruit slices.....	174	0.6	46.5	26.4	22.4	2.3	0.0	1.2	0.0	0.6				28.7	35.1	32.2	4.0			
Corn-meal agar.....	800	0.1	9.8	23.9	40.9	13.5	6.8	3.5	1.1	0.3	0.1	0.1		23.6	28.5	31.8	15.1	0.9	0.1	
4 isolates from fruit of Deglet Noor date palm																				
Czapek's agar.....	800	0.3	22.1	21.4	40.6	7.6	5.3	1.5	0.5	0.3	0.3	0.0	0.3	19.1	31.0	34.6	13.3	1.5	0.5	
Citrus fruit slices.....	214	5.6	53.7	23.8	15.9	0.5	0.5							37.4	29.9	27.6	5.1			
1 isolate from fruit of Holguin guava																				
Corn-meal agar.....	40		7.5	42.5	40.0	5.0	2.5	2.5						10.0	27.5	47.5	15.0			

orange isolates and 85 per cent of those from date had either no beaks or beaks up to  $7.6\ \mu$  in length.

The response of *Alternaria* on sterile fruit slices of Washington Navel orange, Valencia orange, and Eurkea lemon was very different from that on Czapek's agar. The fungus on citrus fruit slices produced much aerial mycelium with relatively few spores, while on Czapek's agar it produced little aerial mycelium with many significantly longer and broader spores. More than 90 per cent of the spores from orange and date isolates, when grown on sterile slices of citrus fruit, were from  $10.4$  to  $26.5\ \mu$ , mostly  $13.1$  to  $15.7\ \mu$ , in length (table 1). Only about one third of the spores were beaked, and these beaks were mostly less than  $7.6\ \mu$  in length.

Abundant sporulation was obtained on corn-meal agar. Spores from these cultures were similar in length to those on Czapek's agar (table 1), but they were somewhat narrower, and their beaks had greater mean length.

Spores with 1 to 4 transverse septa were relatively common in all cultures; the extreme range of variation was from 0 to 11 septa (table 2). On Czapek's agar and on corn-meal agar, 40.6 to 51.5 per cent of the spores were 3-septate. About half of the spores from citrus fruit slices were 1-septate, however, and less than one fourth of them were 3-septate. Spores with 2 longitudinal septa were most common on the agar media, and spores with 1 or no longitudinal septum were most common on citrus fruit slices.

The number of spores in spore chains was easily observed in cultures on the agar media but not in cultures on citrus fruit slices, because of the aerial mycelium. The spore chains on corn-meal agar had noticeably more spores than those on Czapek's agar (table 3). Whereas 6-spored chains were most numerous on corn-meal agar, 4-spored chains were most numerous on the other. One chain of 17 spores was observed on corn-meal agar.

About 40,000 spores were examined for beaks (table 4). Of these spores, grown on the different media, the following percentages were beaked: on citrus fruit slices, 31.1 to 37.8 per cent; on Czapek's agar, 61.1 to 62.9 per cent; and on corn-meal agar, 84.9 to 87.5 per cent.

It was commonly observed that the length of individual spores in a chain tended to decrease more or less regularly from the oldest

TABLE 3  
PERCENTAGE DISTRIBUTION OF SPORE CHAINS OF *ALTERNARIA CITRI*, ACCORDING TO NUMBER OF SPORES IN CHAINS,  
WHEN ISOLATED FROM VARIOUS FRUITS AND CULTURED ON DIFFERENT MEDIA

Culture medium	Num-ber of spore chains exam-ined	Percentage of spore chains having the given number of spores															
		Number of spores															
		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
21 isolates from fruit of Washington Navel orange																	
Czapek's agar.....	903	0.5	16.2	25.4	23.5	15.1	10.7	5.5	2.0	0.9	0.2						
Corn-meal agar.....	680		0.3	4.0	13.0	20.4	19.7	15.9	10.9	7.8	4.7	2.4	0.3	0.3	0.0	0.0	0.2
4 isolates from fruit of Deglet Noor date palm																	
Czapek's agar.....	410	1.2	9.3	20.3	19.3	15.1	11.2	9.8	5.3	5.3	1.2	1.5	0.2	0.2			

TABLE 4

PERCENTAGES OF BEAKED SPORES IN CULTURES OF *Alternaria Citri*,  
FROM VARIOUS ISOLATES GROWN ON DIFFERENT MEDIA

Culture medium	Number of spores observed	Beaked spores	
		Number	Per cent
21 isolates from fruit of Washington Navel orange			
Czapek's agar.....	14,305	8,734	61.1
Citrus fruit slices.....	3,750	1,167	31.1
Corn-meal agar.....	11,755	10,294	87.5
4 isolates from fruit of Deglet Noor date palm			
Czapek's agar.....	6,074	3,820	62.9
Citrus fruit slices.....	4,439	1,681	37.8
1 isolate from fruit of Holguin guava			
Corn-meal agar.....	575	488	84.9

to the youngest—that is, from the proximal to the distal end of the chain. All the mature spores in 31 chains were measured. Although variations were observed in certain instances, the mean length of the spores, taken consecutively and beginning with the oldest in each chain, decreased in order from no. 1 to no. 8 (table 5). Irregularities in the results beyond this point are attributed to the small number of individuals measured.

Characters such as spore size and the tendency to produce beaks have been markedly influenced in these studies by the different kinds of nutrient media used. At first we thought that *Alternaria Citri* might respond most favorably when grown on fruit of the Washington Navel orange, but this was not the case. Slices of citrus fruit were poorly suited for culture media, because when grown on this fruit, the spores of the fungus were relatively small, thin-walled, nonbeaked, smooth, and light-colored, as compared with those grown on agar. Also, spore chains, on citrus fruit slices, were either absent or obscured by masses of aerial mycelium.

That *Alternaria Citri* was first described and named in relation to a disease of citrus is no reason why it should necessarily appear

TABLE 5

LENGTH OF CONSECUTIVE SPORES IN SPORE CHAINS OF *ALTERNARIA CITRI* \*

Spore no.	Total number of spores measured	Spore length	
		Range ( $\mu$ )	Mean ( $\mu$ )
1	31	14.63-49.40	30.38
2	31	15.58-41.30	26.72
3	31	13.30-31.35	22.42
4	30	13.30-35.53	21.53
5	24	12.35-34.20	19.80
6	16	13.30-27.55	19.24
7	12	7.60-29.45	17.41
8	3	8.74-20.90	15.26
9	2	17.10-22.80	19.95
10	2	15.20-19.00	17.10
11	1		14.25
12	1		9.50

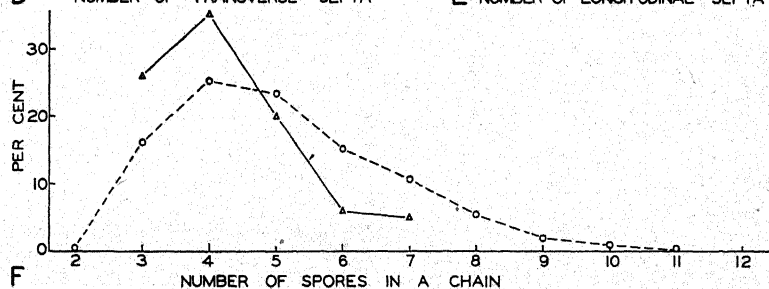
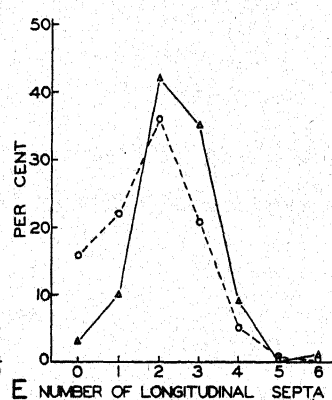
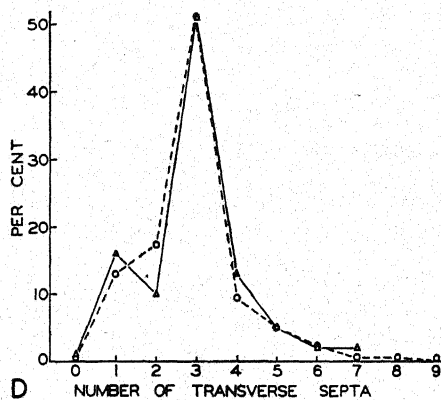
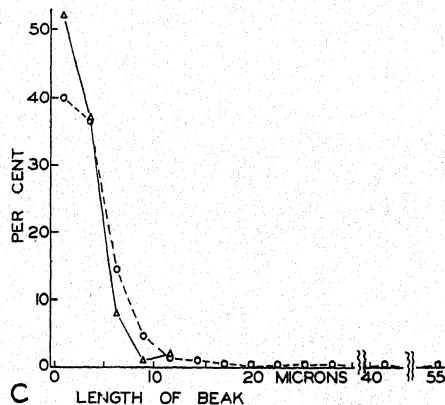
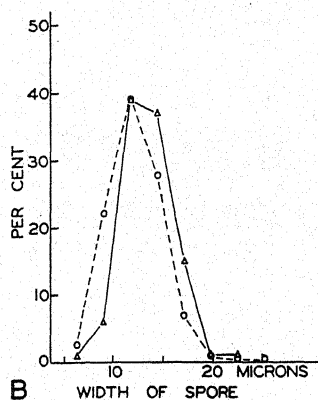
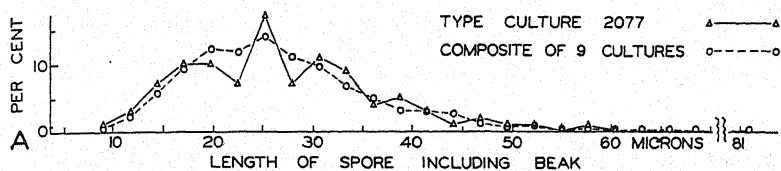
\* All spores except the youngest or terminal spore in each of 31 spore chains were measured in order, from the proximal to the distal end of each chain.

most vigorous and natural while attacking citrus fruit. Furthermore, as found imbedded in the ripening flesh of the date, *A. Citri* is difficult to recognize except by the usual methods of isolation and culture. In the date, the mycelium is sterile and composed of greatly swollen cells, some of which are  $30\mu$  in diameter. The appearance of isolates on agar *in vitro* is therefore the primary basis on which we have formed our concept of the species.

Apparently, Elliott (12) did not study *Alternaria Citri*, but he demonstrated, in seven other species of *Alternaria*, variations in spore size which were induced by different types of nutrient media. Elliott also observed that "slight changes in media may cause great changes in the submerged mycelium."

Such variations in growth response emphasize the need for a standard cultural environment and laboratory technique in connection with the description and identification of *Alternaria* spp. We have found Czapek's agar (see footnote 6) to be a favorable

FIG. 3. Percentage-distribution curves of type culture 2077 and of a composite of nine cultures of isolates 2060, 2061, 2062, 2063, 2065, 2067, 2069, 2077, and 2080 of *Alternaria Citri* from Washington Navel orange. A, length of spore, including beak; B, width of spore; C, length of beak; D, number of transverse septa; E, number of longitudinal septa; and F, number of spores in spore chains. Curves for culture 2077 represent measurements of 100 spores; those for the composite, 1,000 spores.





culture medium for the growth and sporulation of *A. Citri*, and because its definite chemical composition can be easily duplicated, we have used this medium in the preparation of our neotype material.

Cultures of *Alternaria Citri* often become sterile when grown for extended periods on the common laboratory media. At first an isolate may sporulate profusely and have little aerial mycelium. After repeated subculturing, however, the tendency toward sterility will be marked by a gradual reduction in the length of the spore chains, an increase in the number of large, single, irregularly shaped conidia, and the development of much aerial mycelium. Devitalized cultures of this kind are atypical and should not be included in morphological studies. For these reasons the related strains of *Alternaria* may be best identified when freshly isolated cultures are grown and observed under standard laboratory conditions.

Our isolates of *Alternaria Citri* have shown considerable variation in the length of spore chains and in the tendency of the chains to branch when grown on different media. Since most of the spores within a chain are beaked, while the terminal spore is not, the percentage of beaked spores is relatively higher in cultures having long, straight spore chains than in those having short spore chains or chains in which there is much secondary branching.

It has been shown that the spores in a chain tend to decrease in length from oldest to youngest. This is perhaps due to the relative availability of food at different points along the spore chain. In this acropetal type of sporulation, the first or oldest spore grows directly from the conidiophore; but the second spore, at the apex of the first, must obtain its food by translocation through cells of the first spore. Similarly, food for succeeding spores must pass through all the older spores in the chain, a process that naturally becomes more difficult at each step. Very long spore chains may have several short, swollen cells (one-celled spores) near the distal end (FIG. 5, J). These diminutive spores may darken and have small beaks, but normal enlargement does not occur. A similar effect on spore size may also result from the branching of the spore chain. Smaller spores develop after the food stream has been divided.

Wakefield (37) suggested an interesting but somewhat ques-

tionable theory regarding the length distribution curve for conidia of *Alternaria Brassicae* var. *Citri*. The curve for the conidia, which varied in length from 9 to 44  $\mu$ , was complex and was thought to represent a composite curve consisting of a series of smaller, overlapping and interesting curves. Wakefield suggested that each of the smaller curves may possibly correspond to a conidium of fixed position with reference to the conidiophore and in relation to the other conidia in the chain.

The primitive nature of *Alternaria Citri* within the *Alternaria-Stemphylium* group is suggested by the morphological similarity between the spores and the mycelium (FIG. 1). A spore of this species resembles a segment of the mycelium containing one or more cells. Such a "segment" is hyaline and slender at first but becomes darkened and more or less swollen with age. Secondary cell division may also occur in this "segment." The cells of this "segment" are reasonably uniform in size, although the number may vary considerably. Each cell may germinate separately and may therefore be regarded as a potential spore and equivalent to any hyphal cell in the asexual propagation of the fungus.

A spore chain of *Alternaria Citri* resembles a branch of the mycelium. Division and elongation of cells occur near the distal end, where a principal axis of growth predominates. Branching may occur along the sides of this "mycelial branch." Certain long, slender spores, such as that shown in figure 5, C, are little more than extension joints in the conidiophore. All that distinguishes them from the conidiophore is a slight swelling, a somewhat darker color, and the ability to break apart from other segments in the chain. We regard *A. Citri* as a primitive fungus—one that is so little specialized in form that it cannot be sharply defined.

An *Alternaria*-like fungus was cultured by the junior author from *Phoenix dactylifera*, at Golea, Algeria, January 30, 1934. Wiltshire, who identified the organism as *Alternaria hispida* (Harz) Oudemans 1902, states, in correspondence: "It is not a true *Alternaria* as the spores do not separate from each other nor from the conidiophore and is probably the same fungus as *Phoma conidiogena* Schnegg 1915."<sup>9</sup> Thus we see a morphological similarity between members of two widely separated form genera.

<sup>9</sup> Wiltshire, S. P. Letter to H. S. Fawcett. June 7, 1935.

The principal difference, except for the so-called *Phoma* stage, is the ability of the spores to break apart.

In the present study, the similarity between certain isolates from citrus, date, and guava indicate that *Alternaria Citri* may have a rather wide, indefinite range. In selecting a type to represent our concept of the species, however, we considered only single-spore cultures from isolates from fruit of Washington Navel orange. Curves of frequency distribution, based on measurements of 100 spores each, were prepared to illustrate the amount of variability encountered. The curves for spore length were remarkably broad and flat, whereas those for width were comparatively steep (FIG. 2).

Nine single-spore cultures from isolates nos. 2060, 2061, 2062, 2063, 2065, 2067, 2069, 2077, and 2080, were selected to represent the range of variations observed in *Alternaria Citri*. Composite curves constructed from the combined data of these nine cultures were compared with the corresponding curves of the separate cultures. The composite curves agreed most perfectly with those of culture 2077, from Riverside, California. Culture 2077 was therefore judged to be the most representative member of the group and was selected to typify our concept of the species (FIG. 3).

The graphic illustrations of spore measurements, septations, and catenulation, shown in figure 3, give a quantitative picture of variations in *Alternaria Citri*, not only for our type culture but also for the group of cultures from which our type was selected. These curves (FIG. 3) may be of value in identifying other isolates under conditions of similar laboratory technique.

To test our technique, subcultures of culture 2077 were grown on freshly prepared Czapek's agar for 20 days at 26° C. Measurements of a random sample of 100 spores gave distribution curves for length, width, length of beak, and for numbers of transverse and longitudinal septa that were essentially similar to those of the original measurements (FIG. 3). The spore chains in these later cultures, however, were longer than those previously observed: they ranged from 3 to 10 spores per chain, the largest class (27 per cent) containing 7 spores. Differences in age may have caused this discrepancy, for spore chains in the original cultures were examined when the cultures were 10 to 14 days old, while the later ones were examined after 20 days. As a diagnostic char-

acter, the number of spores in a chain may therefore be less reliable than spore size and septation.

#### EMENDED DESCRIPTION OF SPECIES

The original specific characterization of *Alternaria Citri*, accredited to Ellis and Pierce and published by Pierce (26), was as follows:

**"*Alternaria citri*, n. sp.**—In oranges in California. Effused, olivaceous, becoming nearly black. Mycelium abundant, loosely interwoven, gray, consisting of slender, septate, yellowish or olivaceous-hyaline threads, penetrating and overrunning the matrix, much branched, the branches mostly a little swollen at the apex and bearing the terminal variously shaped conidia, which are obovate, oblong-elliptical or subglobose at first,  $10-22 \times 8-15 \mu$  diam., and mostly 3-septate, finally large,  $25-40 \times 15-25 \mu$ , short-clavate-oblong, 4-6-septate and slightly constricted at the septa, the cells divided by one or more longitudinal septa, dark olive-brown. The conidia are oftener 3-6-catenulate in series, either simple or branched. As shown by cultures, secondary conidia often arise directly from the primary, thus giving rise to a secondary series. The cells of the conidia at maturity incline to assume a spherical shape, and the conidia then resemble somewhat asci filled with globose sporidia."

From its habitat, inside the orange, and the character of the conidia, Pierce (26) concluded that *Alternaria Citri* was distinct from *A. tenuis* Nees on orange leaves. No type specimens were mentioned by Pierce and none have been found in the Ellis Herbarium. Recently, a photographic copy of Pierce's unpublished original illustrations( the only ones known to exist) of the black rot of oranges and the spores of *Alternaria Citri* (FIG. 4) was graciously loaned to the writers by Mrs. Newton B. Pierce, of Santa Ana, California.<sup>10</sup>

The emended description follows:

<sup>10</sup> An unpublished manuscript entitled "Black Rot of Navel Oranges," by Newton B. Pierce, was also loaned by Mrs. Pierce. A typewritten copy of this manuscript, probably written during the period 1893-1901, is on file in the Library of the University of California Citrus Experiment Station, Riverside, California. The paper deals principally with economic and pathological phases of the subject.

***Alternaria Citri* Ellis & Pierce em.**

Coloniae in agar *Czapekii* effusae, griseae, olivaceo-brunneae vel atrae, in adversum obscurae; myceliis septatis, ramosis, 2.7–6  $\mu$  in diam., primum hyalinis et tenuibus, demum brunnescentibus et inflatis; conidiophoris simplicibus ramosisve, septatis, tenuibus, ad apices non inflatis, 3–5  $\mu$  in diam., olivaceo-brunneis, hilis terminalibus et interdum lateralibus praeditis; conidiis acropetalis, 2–7-catenulatis vel solitariis, pallidis usque olivaceo-brunneis, vetustis obscarescentibus, glabris vel verrucosis, plerumque obclavatis vel ovoideis, rostratis vel erostratis, muriformibus, septis transversis 0–7 (plerumque 2–4), longitudinalibus 0–6 (plerumque 1–4), magnitudine variis, rostro apicali incluso 8–60  $\mu$  (plerumque 10–37  $\mu$ ) longis, 6–24  $\mu$  (plerumque 8–16  $\mu$ ), latis; rostris plerumque 0–8  $\mu$  longis, hyalinis vel pallide brunneis, hilo apicali praeditis; catenulis sporarum simplicibus vel ramosis, rectis.

Hab. in fructibus *Citri sinensis* (L.) Osbeck, Riverside, California.

Colony on Czapek's agar rapid growing, effused, somewhat zonate, gray, olive-brown to dull black; reverse dark gray, purplish or brownish black; outline irregular. Mycelium septate, branched, 2.7–6  $\mu$  in diameter, at first hyaline and slender, becoming brownish and swollen (FIG. 5, G, H). Conidiophores simple or branched, septate, slender, not swollen at apex, 3–5  $\mu$  in diameter, olive-brown, with terminal and sometimes lateral spore scars (FIG. 5, C–F). Conidia acropetal, 2–7-catenulate or solitary, light to olive-brown, darkening with age, smooth to verrucose, variously shaped, mostly obclavate or oval, beaked apically or laterally, or nonbeaked, slightly restricted at the septa, muriform, with 0–7 (mostly 2–4) transverse and 0–6 (mostly 1–4) longitudinal septa, size variable, length (including apical beak) 8–60  $\mu$  (mostly 10–37  $\mu$ ), breadth 6–24  $\mu$  (mostly 8–16  $\mu$ ); beaks mostly 0–8  $\mu$  long, blunt or rounded, 0–3-septate, hyaline or light brown, with spore scar at apex (FIG. 5, A, B). Spore chains simple or branched, erect, arising from or near apex of conidiophores or directly from conidia (FIG. 5, C, H–J).

Habitat: Fruit of Washington Navel orange, *Citrus sinensis* (L.) Osbeck, Riverside, California.

Neotype specimens on which the emended description is based, grown on Czapek's agar, have been deposited in the Mycological Collections of the Bureau of Plant Industry, Beltsville, Maryland. Coneotypes are deposited in herbaria, as follows: University of California, Berkeley, California; University of California Citrus Experiment Station, Riverside, California; Florida Agricultural Experiment Station, Gainesville, Florida; New York Botanical Garden, Bronx Park, New York City; Imperial Mycological Insti-

tute, Kew, Surrey, England; Plant Pathological Division, Instituto Biologico, São Paulo, Brazil; and Department of Agriculture, Pretoria, Union of South Africa.

The principal differences between the original and the emended descriptions of *Alternaria Citri* may be attributed to the effect of different substrates on the development of this fungus. The spores illustrated by Pierce (FIG. 4) resemble spores that we have seen on flesh of decayed citrus fruits. Most of the spores shown in figure 4 (several of which had germinated) were probably taken from fruit, because a penciled notation (by Pierce) specifies that a chain of four conidia near the upper right-hand corner of the plate are "culture spores." This, together with inferences in the written description, suggest that, although Pierce's concept of the species was based largely on the condition *on* and *within* the fruit, he studied the fungus both in the orange and in artificial culture. That secondary conidia and spore chains are best demonstrated in cultures has also been our experience.

The relative importance of a slight apical swelling in the conidiophores of *Alternaria Citri* is a matter of opinion. Some conidiophores are "a little swollen at the apex," as indicated in the original description, although the emended description does not mention this fact. We have stressed the unswollen conidiophore of *Alternaria Citri* because it is typical of the species, and also because it represents one of the cardinal points of distinction between *Alternaria* and *Stemphylium*, as defined by Wiltshire (38, 39).

In the original description, Pierce (26) states that conidia of *Alternaria Citri* are at first relatively small ( $10-22 \times 8-15 \mu$ ) but finally become large ( $25-40 \times 15-25 \mu$ ). This would indicate that only the larger spores are mature. If one may judge, however, from the dark color of many small spores in cultures where growth has ceased, and from the ability of these spores to germinate, it would seem that the conidia may reach morphological and physiological maturity throughout a much wider range of sizes. The emended description defines this range as  $8-60 \times 6-24 \mu$ .

#### TAXONOMY

We are indebted to Mason (19) and Wiltshire (38, 39) for their studies of the early literature and source material of *Alternaria*

Nees, *Macrosporium* Fries, and *Stemphylium* Wallroth. Much of this literature and material was not available to us.

Wiltshire (38), after studying the available specimens and discussing the basis for the names *Alternaria* and *Macrosporium*, concluded that, except for species having sarciniform spores, such as

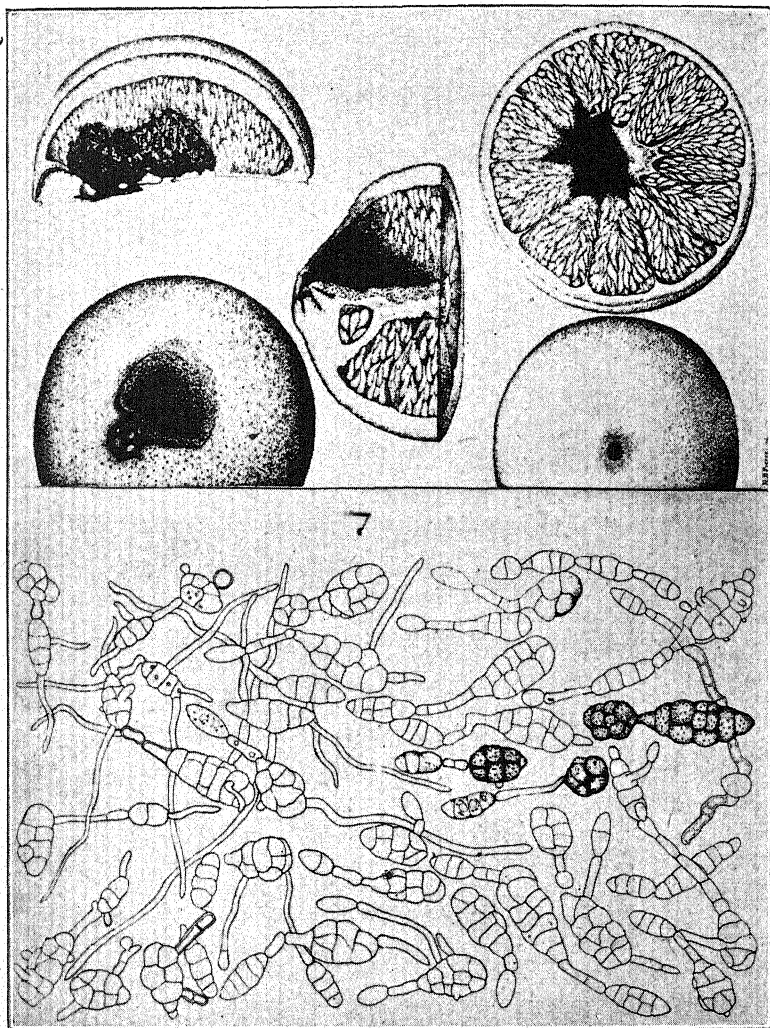


FIG. 4. Photographic copy of two hitherto unpublished, original illustrations by Newton B. Pierce. Above, fruits of Washington Navel orange showing symptoms of black rot; below, spores of *Alternaria Citri*.

*Macrosporium sarciniforme* Cavr., the name *Alternaria* should be used for most of the species now called *Alternaria* and *Macrosporium*, and that *Macrosporium* should be placed in the list of *nomina ambigua*. *A. tenuis* Nees was considered the type for the genus *Alternaria*.

Later, Wiltshire (39) studied specimens of *Stemphylium botrysum*, by Wallroth, who founded the genus *Stemphylium* in 1833, and concluded that this fungus was the same as that known in the literature later as *Macrosporium sarcinula* Berk., the conidial stage of *Pleospora herbarum* (Pers.) Rab. He concluded that these forms of *Macrosporium* constitute the true *Stemphylium* of Wallroth. Wiltshire thus put part of *Macrosporium* into *Alternaria* and part into *Stemphylium*. The characters which distinguish *Stemphylium* from *Alternaria*, as thus understood by Wiltshire, are (1) conidiophores swollen at the apex, (2) growth of the conidiophores continued through the terminal scar, and (3) an oval, subangular spore "frequently constricted at the major median transverse wall and never beaked."

The fungus considered in the present paper is one of the forms that fall in the group commonly known as *Alternaria*, and is similar in general to the modern concept of *A. tenuis*, but apparently not to that illustrated by Nees. It is characterized by conidiophores that are not swollen at the apex and by beaked spores that are frequently borne in chains.

Since 1923, *Alternaria Citri*, or a very similar species, has been identified in California more than 160 times. The isolates, originating from fruit rots and spots on leaves and fruit in several localities in the state and from various species and varieties of *Citrus*, have been roughly identified by their character of growth in culture. This fungus has also been isolated many times in California from date palm (*Phoenix dactylifera* L.) and less frequently from avocado (*Persea gratissima* Gaertn.), guava (*Psidium Guajava* L.), and from *Cneoridium* sp.

Spores similar to those of *Alternaria Citri* have been identified in 24 collections from *Citrus*, represented by specimens in the herbarium of the University of California Citrus Experiment Station. Among these are specimens from 16 localities in California, and others from Phoenix, Arizona; Palermo, Sicily; Monzel bon zelf,



Tunis; Damietta, Egypt; the Televiv region of Palestine; from Asuncion, Paraguay; and from Montevideo, Uruguay. Similar types of spores have been noted in photomicrographs sent by Dr. S. P. Wiltshire, from citrus specimens originating in Portugal, Cyprus, Southern Rhodesia, and the Union of South Africa; they have also been noted in isolates from citrus taken in Florida, Italy, Egypt, and Australia.

Relatively large variations in spore size were found in the individual cultures and specimens studied. In general, these variations were of similar magnitude. In comparing the fungus in one culture or specimen with that in another culture or specimen, there seemed to be no natural grouping that would suggest differences in specific rank. Differences have often been noted in the development of mycelium and in the degree of sporulation, but these have not remained constant in culture. Differences in such unstable characters have been regarded as insufficient cause for the separation of species. In correspondence, Wiltshire<sup>11</sup> has pointed out that some isolates appear to have a larger percentage of long-beaked spores than others and that this feature might serve to separate certain types. It is our observation that spores in certain cultures may show all gradations between no beaks and moderately long beaks. Since, in our experiments, the type of media has greatly influenced the percentage of beaked spores, and even the average length of the beaks, it would seem unwise to separate different strains of *Alternaria* on the basis of this character unless the fungi are compared under uniform conditions. Because of the wide variations in size and shape of spores in any specimen, the fungus should be cultured and subjected to considerable study before any separation is attempted.

The following species of fungi are now considered by us to be similar to *Alternaria Citri*. The first of these (*Stemphylium Citri*) is probably identical; the others are similar but not certainly the same.

*Stemphylium Citri* was described in 1910 by Patterson and Charles (22), from end rot of oranges in Arizona. Examination and spore measurements of the fungus on microscope slides loaned by the United States Department of Agriculture, Bureau of Plant

<sup>11</sup> Wiltshire, S. P. Letter to H. S. Fawcett. June 7, 1935.

Industry, show that it is indistinguishable from *Alternaria Citri*. This fungus is not a true *Stemphylium* as understood by Wiltshire (39), because the conidiophores are not swollen at the apex and the spores are beaked.

*Macrosporium Citri* was described in 1899 by McAlpine (20) on leaves of lemon in South Australia. In addition to the description and figures published by McAlpine, we have examined only a photograph of drawings by Wiltshire of a few spores from the type specimen. In size and septation, the spores of this fungus are reasonably similar to those of *Alternaria Citri*, but the spore body appears thicker and the beak more slender. *M. Citri* apparently belongs in the genus *Alternaria*, but the question of its identity with *A. Citri* Ellis and Pierce must await further study.

There is a remarkable similarity between *Alternaria Mali* Roberts and *A. Citri*, if we may judge from the published description and illustrations (29). *A. Mali* is reported by Roberts (29) to be "found constantly associated with characteristic spots on apple leaves from Virginia, Maryland, Tennessee, Arkansas, and Missouri." Doidge (11) states that "*A. Mali* is similar in morphology to *A. tenuis* and *A. Citri*." She investigated the pathogenicity of *A. Mali*, *A. tenuis*, and various strains of *A. Citri* on apple, cherry, and citrus leaves, and on citrus fruits. Certain minor physiological differences were noted, but all strains produced decay in citrus fruits.

Strains attributed to *Alternaria tenuis* Nees, reported on figs from California and Virginia by Brooks and McColloch (6), also bear a strong resemblance to *A. Citri*.

Important details in the original concept of *Alternaria tenuis* are obscure, since there is no mention of spore dimensions in the description published by Nees in 1817 (21). Nees's figure, reproduced by Wiltshire (38), shows chains of 2 to 4 spores, with filiform connections (beaks) that are approximately the same length as the spore bodies. Other illustrations of *A. tenuis* by Corda (10), Saccardo (32), Penzig (23), Berlese (4), Elliott (12), and Bolle (5), also reproduced and discussed by Wiltshire (38), indicate that the concept of this species has varied considerably from that of Nees. In one of the more recent concepts, such as that represented by Penzig (24) on citrus leaves, the spores are small

and close together in chains, with very short or no beaks. On the basis that *A. fasciculata* (Cooke & Ellis) Jones & Grout is a synonym of *A. tenuis* as studied by Bolle (5), Mason (19) referred to *A. tenuis* specimens "whose spores are obclavate, borne in long chains, and the majority of whose spores have 3 to 5 cross-septa, and, especially in culture, fall within the limits 20 to 50  $\times$  10 to 14  $\mu$ ." Among the species referred to *A. tenuis* or the *A. tenuis* group by Mason (19) are *A. Mali*, and *Macrosporium Citri*. Wiltshire (38) states that "the group of fungi which has in recent years come to be known as *A. tenuis*" should, in his opinion, be indicated as *A. 'tenuis'* auct., thus indicating that the name is not valid but that a better name is not available at present. In the course of time the specific limits of the different forms included in the group may be better understood and until this has been done the suggestion made seems the most practical under the circumstances."

In correspondence, Shear has suggested that "since there seems to be no type or authentic material of *A. tenuis*, it would be desirable to select a specimen from some other source to designate as the neotype. In this case we find that Saccardo issued in his exsiccati *Mycotheca veneta* No. 297 what he considers to be this species. Since this is a well known series of specimens and is accessible in most large herbaria and is the basis of modern interpretations it would seem that it would be quite proper to designate this as the neotype."<sup>12</sup>

Spores of the above-mentioned specimen attributed to *Alternaria tenuis* Nees by Saccardo were mounted on a microscope slide and loaned to us through the courtesy of Mr. J. A. Stevenson, of the United States Department of Agriculture. Among 530 spores examined, 79 per cent were beaked; of these, many were imperfect, the apex of the beak having been broken. Nearly all the spores were shriveled somewhat, and the length of the beak was not easily determined because the color of the spores had apparently faded.

In comparing spores from our isolates of *Alternaria Citri* with those from the Saccardo specimen of *A. tenuis* (table 6), we found noticeable differences in the mean lengths, with and without beaks, and in the mean lengths of beaks alone. That spores of *A. Citri*

<sup>12</sup> Shear, C. L. Letter to H. S. Fawcett. October 28, 1943.

TABLE 6  
SPORE DIMENSIONS OF *Alternaria Citri*\* AND *A. tenuis*† COMPARED

Spore measurement	<i>A. Citri</i> ( $\mu$ )	<i>A. tenuis</i> ( $\mu$ )
Length:		
Range, with beak.....	8.1-81.0	10.3-56.2
Range, with beak (86.9 per cent of population) ‡.....	10.4-37.3	21.2-45.4
Mean, with beak.....	26.9	32.9
Mean, without beak.....	23.3	27.0
Mean, beak alone §.....	5.5	8.6
Width:		
Range.....	6.3-24.3	7.2-14.4
Range (89.3 per cent of population) ‡.....	7.7-15.7	7.7-13.0
Mean.....	12.2	11.2

\* Based on measurements of 1000 spores from isolates from Washington Navel orange on Czapek's agar.

† Based on measurements of 100 spores of *A. tenuis* Nees from Saccardo's exsiccati *Mycotheca veneta* No. 297. *Leguminibus putrescentibus "Lathyrus latifolii"* [*Lathyrus latifolius* L.] September, 1874, Selva (Treviso), Italy. (Loaned by U. S. Dept. of Agriculture.)

‡ Smallest and largest measurements omitted from the range of total population.

§ This calculation includes beaked spores only.

had a greater range of length may be attributed in part to the larger number of measurements made for this species. It seemed significant, however, that when 13.1 per cent of the spore population (that portion of the population including the shortest and longest spores) was omitted, the range of spore lengths, with beaks, was 10.4-37.3  $\mu$  for *A. Citri* and 21.2-45.4  $\mu$  for Saccardo's specimen of *A. tenuis*.

*Alternaria tenuis*, as represented by the Saccardo specimen, does not seem to correspond either with the original figure and description of Nees (21) or with the more recent concepts of Elliott (12) and Bolle (5). The range of spore sizes indicated by our measurements of the Saccardo specimen agrees rather closely with that indicated for *A. tenuis* by Mason (19), but neither agrees with that of *A. Citri* as we have studied it. If the Saccardo specimen were to be designated the neotype for *A. tenuis* Nees, we should assume that it was from the same host plant and from the same general locality as the original material. Since these assumptions would probably be false, and since the spores of the Saccardo specimen differ noticeably in shape from those figured by Nees

(21), we are not inclined to consider the Saccardo specimen as the neotype of *A. tenuis* Nees.

It seems to us that the real *Alternaria tenuis*, if it can be determined, should have beaks averaging about the same length as

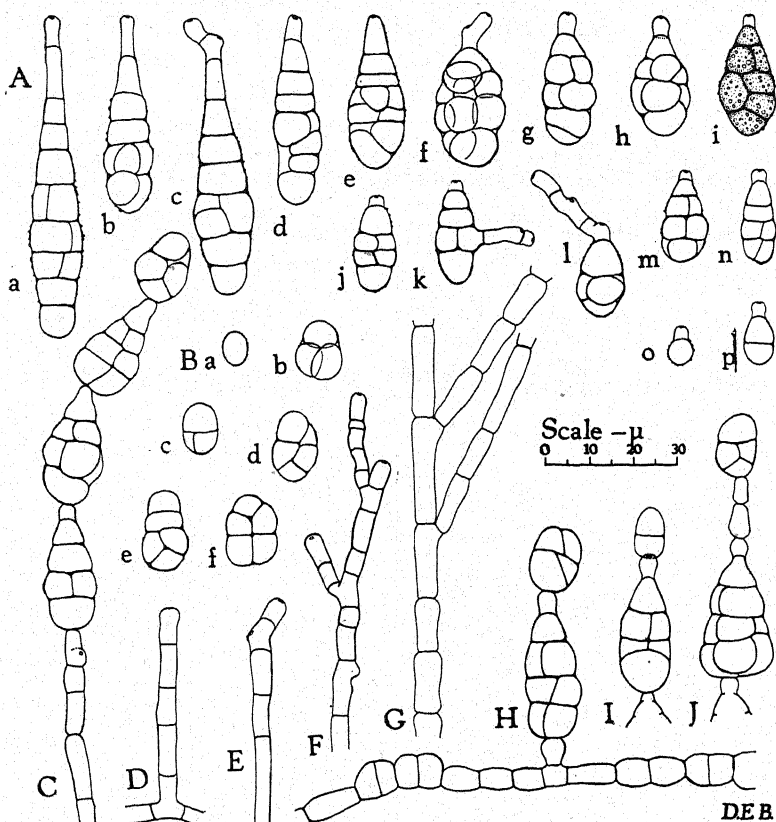


FIG. 5. *Alternaria Citri*. A, a-p, spores with beaks; B, a-f, spores without beaks; C, conidiophore with spore chain; D-F, conidiophores; G, young mycelium; H, old mycelium with spores attached; I, apex of spore chain showing formation of young conidium; J, apex of spore chain showing two short, swollen cells (spores) near the distal end. (All  $\times 000$ .)

the spore body rather than the nonbeaked or short-beaked form now attributed to it. Although the spores of *A. Citri*, as we have observed them, are characterized by short beaks and no beaks, the percentage of beaked spores and the average length varying somewhat with the type of medium, the question arises as to whether

some of the specimens identified as *A. tenuis* Nees in recent years may not be good representatives of *A. Citri*.

Wiltshire, in correspondence, states that "*A. tenuis* auct.' has been consistently interpreted by Elliott, Bolle and others as a species which rarely if ever has a definite beak. The name is well established in the literature in this sense but as it is applied to a fungus different from that Nees had, it will be necessary to give '*A. tenuis* auct.' a new name unless it can be shown to have another earlier valid name."<sup>13</sup>

Elliott (12) tentatively divides the species of *Alternaria* and *Macrosporium* into six groups "of similar forms which may be identical, and which are undoubtedly closely allied." He suggests that "these groups might well be retained to indicate the similarity of a number of forms such as is exemplified in bacteriology in the *B. [Bacterium] coli* and *B. [Bacillus] subtilis* groups," and that each group "should be designated by a typical species." Elliott's *A. tenuis* group is characterized by spores ranging in size from  $11-50 \times 7-20 \mu$ , not including the beaks. According to his observations, "the spores are quite variable in form as well as in size but are generally broad and muriform." He lists 37 and possibly 46 species in this group. *A. Citri* is not listed but it would also belong here.

Young (40) produced 165 "new diseases" by means of cross-inoculations with species of *Alternaria* and *Macrosporium*, under laboratory and greenhouse conditions. The production of disease symptoms on hosts not previously recorded, indicated that many species of these genera are facultative parasites with wide experimental host ranges.

In a compilation of the species of *Alternaria* and *Macrosporium* included in Saccardo's *Sylloge Fungorum*, Young (41) lists more than 100 species with spore dimensions falling within the extreme range of sizes here attributed to *A. Citri*. Although spore dimensions are not the only important characters on which these species are separated, it is evident that much synonymy exists.

We have shown that *Alternaria Citri* has short-beaked or non-beaked spores representing a relatively wide range of sizes. The emended description includes several closely related species which

<sup>13</sup> Wiltshire, S. P. Letter to D. E. Bliss. January 25, 1944.

have wide geographic distribution and host range. The name *A. tenuis*, although no longer valid, has in recent years been applied to a group of fungi which resemble *A. Citri* more than they resemble the original description and illustration of *A. tenuis* Nees. While retaining *A. tenuis* as the type species of the genus, it seems desirable, until a comprehensive survey of the genus is made, to regroup the small-spored, short-beaked forms about some other representative species such as *A. Citri*.

#### SUMMARY AND CONCLUSIONS

The fungus *Alternaria Citri*, described in 1902 by Pierce and accredited to Ellis and Pierce, is widely distributed throughout the temperate and subtropical zones but is apparently unknown in the tropics. Confusion regarding the morphological limits of this species has arisen because type specimens and illustrative material are lacking.

New evidence on the morphology and taxonomy of *Alternaria Citri* is presented. This evidence is based on a statistical study of spores and other characters of 26 isolates from fruit of Washington Navel orange, Deglet Noor date palm, and Holguin guava, from various localities in southern California, including some of those localities where Pierce obtained his specimens.

A method, using Czapek's agar, is proposed as a standard laboratory technique for the comparison of isolates and the identification of *Alternaria Citri*. Citrus fruit slices were conducive to the production of much mycelium and relatively few spores; corn-meal agar and Czapek's agar favored abundant sporulation with but little aerial mycelium. Marked differences developed when transfers of the same isolate were cultured on different media. Much similarity was found, however, between various isolates (including those from orange, date, and guava) when cultured under uniform conditions on the same medium.

Measurements of 2629 spores in the present study showed wide ranges of variation, especially in length. Isolates from citrus fruit, on Czapek's agar, produced spores 8.1–81.0  $\mu$  in length, including beaks (86.9 per cent of the spores measuring 10.4–37.3  $\mu$ ), and 6.3–24.3  $\mu$  in width (89.3 per cent of the spores measuring 7.7–

15.7  $\mu$ ). The beaks of these spores were up to 54.0  $\mu$  in length (90.7 per cent, up to 7.6  $\mu$ ). Spores cultured on corn-meal agar were similar in length but somewhat narrower, with longer beaks. The same isolates on citrus fruit slices gave spores, 93.8 per cent of which were only 10.4–26.5  $\mu$  long.

The number of transverse septa in the spores examined ranged from 0 to 11 and were commonly 1 to 4. On Czapek's agar, 40.6 to 51.5 per cent of the spores had 3 transverse septa, but on citrus fruit slices less than 25 per cent had 3 septa and approximately 50 per cent were 1-septate. Among 40,000 spores grown on the different media, the following percentages were beaked: on citrus fruit slices, 31.1 to 37.8 per cent; on Czapek's agar, 61.1 to 62.9 per cent; and on corn-meal agar, 84.9 to 87.5 per cent. The percentages of beaked spores were higher in cultures having long, straight spore chains than in cultures having short or branched spore chains. Terminal spores were mostly nonbeaked; the others were mostly beaked. In general, the average length of the spores in the chains decreased in order from the oldest to the youngest, that is, from the proximal to the distal ends of the chains. This decrease in length may be due to the decreasing availability of food at the distal end of the chain as it lengthens. The spore chains on corn-meal agar were noticeably longer than those on Czapek's agar.

The primitive nature of *Alternaria Citri* within the *Alternaria-Stemphylium* group is suggested by the morphological similarity between the spores and the mycelium. Graphic illustrations of spore dimensions, septation, and catenulation, give a quantitative picture of variations in the species, which may be of value in identifying other isolates.

The principal differences between our emended description of *Alternaria Citri* Ellis and Pierce and the original descriptions, and between our illustrations and those of Pierce's, may be attributed to the effect of different substrates on the development of the fungus. Pierce's concept was based largely on the condition of the fungus *within or on the orange fruit*; ours, on the appearance *in culture*. The fungus may best be identified when freshly isolated cultures are observed under standard conditions.

The fungus considered here is a true *Alternaria*, similar to the modern conception of *A. tenuis* Nees, but not to the conception



suggested by the original illustration of Nees's. Examination of a large number of isolates and herbarium specimens of *A. Citri* has revealed relatively large variations in spore size within the individual cultures and specimens. These variations have, in general, been of similar magnitude. No natural grouping that would suggest differences in specific rank has been noted. Since the type of medium used is found to influence markedly the percentage of beaked spores and the average length of the beaks, any separation of different strains on these characters should be based on comparison under uniform conditions.

Other species of fungi now considered by us to be similar to *Alternaria Citri* are the following: *Stemphylium Citri* Patterson and Charles (probably identical with *A. Citri*), *Macrosporium Citri* McAlpine, *A. Mali* Roberts, and *A. tenuis* Nees as reported on figs by Brooks and McColloch (6). The real *A. tenuis*, if it can be determined, should have beaks averaging about the same length as the spore body, rather than the nonbeaked or short-beaked form now attributed to it. The name *A. tenuis*, although no longer valid, has in recent years been applied to a group of fungi which resemble *A. Citri* more than they resemble the original description and illustration of *A. tenuis* by Nees. While retaining *A. tenuis* Nees as the type species of the genus, we suggest that the short-spored, short-beaked species be tentatively grouped about some other species such as *A. Citri*.

#### ACKNOWLEDGMENTS

Sincere appreciation is expressed to Mrs. Newton B. Pierce for her permission to use unpublished illustrations and to examine an unpublished manuscript by the late Mr. Newton B. Pierce; to Dr. C. L. Shear, Mr. J. A. Stevenson, and Dr. Anna E. Jenkins for helpful advice and the loan of specimens; to Miss Edith K. Cash for the preparation of Latin description; to Dr. S. P. Wiltshire for his constructive criticism of the text; and to Miss Elizabeth Parker for assistance in summarizing the data.

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## ADDITIONS TO THE UREDINALES OF VENEZUELA—IV<sup>1</sup>

FRANK D. KERN AND H. W. THURSTON, JR.

Our studies of the rusts of Venezuela began more than ten years ago. After determining about 1000 collections which were fairly well identified as to hosts, there remained a considerable residue (perhaps 125 collections) in which the hosts were either doubtfully or not identified. Many of these specimens were so sterile or so fragmentary that hope for much aid in host identification seemed improbable.

Many of these specimens bore well developed rusts and looked so interesting that we were loath to give up their further study and investigation. We determined to see what progress we might make by combining our knowledge of rust and host characters. Most every specimen we examined presented the aspect of a "puzzle" but we nevertheless decided to see what we might accomplish through what may be called "circumstantial evidence."

Sometimes we began with a clue from the rust. For example, if the teliospores had two cells, bilaminate walls, and pedicels with appendages, we recognized these as character of the genus *Prospodium*. This genus is known to inhabit the families Verbenaceae and Bignoniaceae. With this start we could begin checking both rust and host with known species and specimens.

The host characters which could be checked were chiefly details of leaf structure pertaining to shape, texture, venation, glands, hairs, and margins. Sometimes we guessed that a host might belong to a certain family. We would then familiarize ourselves with the rusts reported on that family and see whether our rust

<sup>1</sup> Contribution from the Department of Botany, The Pennsylvania State College, No. 143. Publication authorized April 12, 1944, as paper No. 1231 in the Journal Series of The Pennsylvania Agricultural Experiment Station. Previous papers in this series are as follows: Monog. Univ. Puerto Rico B. 2: 262-303, 1934; Mycologia 30: 537-552, 1938; 35: 434-445, 1943; 36: 54-64, 1944.

might be one of them. Many times that procedure brought results. Occasionally we had fortunate accidents. By this we mean that when we were comparing our specimen with a known specimen we found it did not agree but we came to the realization that another one would.

As our studies proceeded we were confident that we were making some "hits." Later we found out that we had made some "near misses." The facts are that we have solved a considerable number of the "puzzles" and the point is that some of our most interesting "additions" to the rust-flora of Venezuela have come out of this residue, which at first seemed so hopeless. The conclusion is that mycological collectors must not fail to take specimens even if the host is sterile and the specimen must be fragmentary. It should not encourage them, however, to be careless or lacking in persistence to get the very best material available. We cannot overemphasize the value of notes about the host. Even such elementary facts as the type of plant—whether shrub, tree or vine—and whether the leaves are simple or compound, alternate or opposite, etc., may turn out to be the "circumstantial evidence" that will lead to a solution.

This report adds 30 species to the Venezuelan rust list. In our first paper published in 1934 the total was given as 184; two errors have reduced this to 182. Our additions in 1938 brought the total to 204, in 1943 to 237, in 1944 to 262, and now to 292.

We must add that after carrying our studies as far as possible we sought the aid of several phanerogamic botanists. They have verified many of our identifications, have put us right on others, and have made some additional difficult determinations. To say that they have rendered valuable assistance is an under-statement. Without their help we could not have reduced the residue to the mere handful as is now the case. Our thanks are due to Dr. E. P. Killip, Dr. S. F. Blake, Dr. P. C. Standley, Dr. H. A. Gleason, Dr. H. K. Svenson, and Dr. R. E. Woodson. We are again indebted to Professor R. E. Dengler, of The Pennsylvania State College, for aid in the preparation of the latin diagnoses of the 12 new species.

**Aecidium Coutareae** sp. nov.

Pycnidiis amphigenis, in greges parvos maculis decoloratis insidentibus, profunde insitis, oblate globosis,  $80-95 \times 96-144 \mu$ ; periphysibus  $40-55 \mu$  longis.

Aecidiis hypophyllis in maculis decoloratis insidentibus, in annulos 2-5 mm. diam. circum pycnidia aggregatis, breviter cupulatis, 0.1-0.2 mm. diam.; peridio albido, margine eroso, aliquantum recurvato; cellulis peridii rhomboideis,  $16-20 \times 29-35 \mu$ ; tunica exteriore 6-7  $\mu$  cr., interiore 3-4  $\mu$ , verrucosa; aecidiosporis late ellipsoideis,  $16-23 \times 21-29 \mu$ ; tunica incolori, ca. 1.5  $\mu$ , minute aequaliterque verrucosa.

On *Coutarea hexandra* (Jacq.) Schum. In Chapparal, near El Sombrero, Est. Guarico, July 20, 1940, C. E. Chardon 4044.

This host belongs to the family Rubiaceae. A number of aecia have been described on various genera of this family but our specimen does not match any species with which we have made comparisons.

**Aecidium Hymemocallidis** sp. nov.

Pycnidiis amphigenis, in greges parvos maculis decoloratis insidentibus, inconspicuis, subepidermalibus, oblate globosis,  $100-130 \mu$  latis; periphysibus fasciculum  $50-65 \mu$  longum efformantibus.

Aecidiis amphigenis, numerosis, in maculis decoloratis insidentibus, in greges orbiculares vel ellipticos 5-10 mm. diam. circum pycnidia aggregatis, cupulatis, parvis, 0.1-0.2 mm. diam.; peridio albido, margine recurvato, lacerato; cellulis peridii imbricatis, e facie polygonis,  $16-21 \times 23-32$ , probabiliter longioribus; tunica exteriore striata ad 6  $\mu$  cr., interiore ca. 3  $\mu$ , verrucosa; aecidiosporis late ellipsoideis,  $16-19 \times 19-26 \mu$ ; tunica incolori, ca. 1.5  $\mu$  cr., minute crebreque verrucosa.

On *Hymemocallis* aff. *caribaea* Herb. El Valle, Caracas, Dist. Federal, May 20, 1941, Fr. Fernandez Yopez 4000 A.

Jackson (Mycologia 18: 154-155. 1926.) reports from Chile two species of *Aecidium* on the family Amaryllidaceae, both on *Alstromeria*. One of these has aeciospores with colored walls and is obviously different. The other is also different in having broader and taller aecial cups. There is a species on *Zephyranthes* from Mexico which differs from our specimen in the character of the peridial cells and in the pycnia.

ANGIOPSORA LENTICULARIS Mains, Mycologia 26: 127. 1934.

On *Lasiacis procerrima* (Hack.) Hitchc. Forests at Rancho Grande, Est. Aragua, April 30, 1938, C. E. Chardon 2629; Rancho Grande, road Maracay a Ocumare de la Costa, Est. Aragua, March

28, 1939, *Chardon & Whetzel 3185*; road Maracay a Choroni, Est. Aragua, April 9, 1939, *Chardon, Whetzel & Müller 3388*.

The type specimen of this species is from Ecuador. It has also been reported from Puerto Rico. In the original description Dr. Mains states that the pores of the urediniospores are inconspicuous. While that is true we have made them out to be 6-8, scattered. This arrangement holds for the specimens from Ecuador and Puerto Rico and ours from Venezuela agree. *Uromyces costariensis* Sydow on *Lasiacis* species has 2-4 equatorial pores. This fact enables one to make determinations with assurance even when only urediniospores are present as in the case of our Venezuelan specimens.

***Bubakia venezuelana* sp. nov.**

Pycnidiis plerumque epiphyllis, inconspicuis, gregariis, in maculis decoloratis insidentibus, subcuticularibus, oblate hemisphericis vel conicis, 48-58  $\mu$  longis, ca. 112  $\mu$  latis.

Uredosoris amphigenis, sparsis, in maculis decoloratis dispositis, ca. 0.5 mm. diam., mox nudis, cinnamomeo-brunneis, pulverulentis, epidermide rupta non visibili; uredosporis late ellipsoideis vel obovoideis, 16-23  $\times$  26-34  $\mu$ ; tunica flavo-brunnea, 1.5-2  $\mu$  cr., subinde ad apicem incrassata 3-5  $\mu$ , sparse prominenterque aculeata; poris obscuris.

Teleutosoris ignotis.

On *Croton* sp. Road to Chirgua, Est. Carabobo, March 8, 1939, *Whetzel & Müller 2951*.

Although the telia are unknown, the pycnial and uredinial characters are such that the relationship to the genus *Bubakia* seems unquestionable. In that genus, subcuticular pycnia have been reported by Jackson (*Mycologia* 23: 466. 1931.) and by Cummins (*Mycologia* 32: 370. 1940.). The aecia of the genus are uredinoid, subepidermal, and without peridium or paraphyses. In our material we are unable to separate aecia (primary uredinia) and secondary uredinia. There are four other species of *Bubakia* described on *Croton*. From the three species of the western hemisphere, *B. Crotonis*, *B. argentinensis*, and *B. mexicana*, our species differs in the combinations of urediniospore characters, especially in markings on the walls. It is sparsely and strongly aculeate as against echinulations in the others. The African species, *B. stratosus*, has coarse markings but the walls of the spores are much thicker and the spores are larger.

ENDOPHYLLOIDES PORTORICENSIS Whetzel & Olive; Olive & Whetzel, Am. Jour. Bot., 4: 51. 1917.

On *Mikania* sp. Ocumare de la Costa, Est. Aragua, March 19, 1938, C. E. Chardon 2488; Rancho Grande, road Maracay a Ocumare de la Costa, Est. Aragua, March 25, 1939, Chardon & Whetzel 3138.

The specimens here cited presented a difficult problem when we began our studies. The rust has the appearance of old aecia and the host was unnamed. Preliminary examination revealed that the rust was not an *Aecidium*. We thought the host of one specimen might be a species of *Eupatorium*. Further studies showed the absence of pycnia and the presence of short waxy columns of spores in sunken cups, surrounded by a peridium made up of verrucose cells. This led to the suggestion that the rust might be *Puccinosira Eupatorii* Lagerh. Our specimen was so old that it was difficult to determine the nature of the spores. They were germinated and so collapsed that we could not make out whether or not they were two-celled. Later, through the aid of Dr. S. F. Blake, the hosts were identified as a species of *Mikania*. This fact, together with the probability that the spores are one-celled, led to the determination of our specimens as *Endophylloides portoricensis*. All of the other characters agree with that species. The species has been reported from the West Indies, Central America, and Colombia.

### **Melampsora Euphorbiae-geniculatae** sp. nov.

Pycnidii hypophyllis, gregariis, numerosis, in maculis decoloratis insidentibus, punctiformibus, dein nigro-brunneis, subcuticularibus, oblate hemisphericis vel truncatis, prominentibus, 33–55  $\mu$  longis, 48–87  $\mu$  latis; periphysibus nullis.

Aecidiis hypophyllis, in maculis decoloratis insidentibus, confluentibus in annulum unum 1–3 mm. diam., flavescens, epidermide bullata diu tectis, tandem plus minusve late apertis, dein pulverulentis, epidermide rupta conspicua; aecidiosporis catenulatis, globosis vel late ellipsoideis, 13–16  $\times$  18–23  $\mu$ ; tunica pallide flava vel hyalina, ca. 1  $\mu$  cr., minute aequaliterque verrucosa.

Uredosoris et teleutosoris ignotis.

On *Euphorbia geniculata* Ortega. Banks of Neveri, near Barcelona, Est. Anzoategui, May 26, 1938, C. E. Chardon 2673.



There are seven species of *Melampsora* described on the genus *Euphorbia*. Of these, three species have aecial stages known and are autoecious. It seems likely that the other four species are also autoecious. None of the species of *Melampsora* on *Euphorbia* have ever been reported from South America. It is possible that our species here described may be identical with one of the species known elsewhere on *Euphorbia*, but that does not seem probable.

***Phakopsora antiguensis* (Cummins) comb. nov.**

*Uredo antiguensis* Cummins, Bull. Torrey Club 67: 613. 1940.

On *Acalypha* sp. Road Petare-Guarenas, Est. Miranda, March 15, 1939, Whetzel & Müller 2972.

*Uredo antiguensis* was described from Guatemala. Dr. Cummins pointed out that the species would perhaps be found to belong in the genus *Phakopsora*. Our specimen from Venezuela has abundant telia. In the Guatemalan specimen the uredinia are grouped whereas in the Venezuelan specimen they are scattered. We believe that two specimens represent the same species. A description of the telia follows:

Telia hypophyllous, subepidermal, indehiscent, surrounding the uredinia, united into a crust 2-3 spores high; teliospores cuboid or oblong,  $10-13 \times 15-26 \mu$ ; wall  $1.5 \mu$  thick, somewhat thicker in the apical spores, cinnamon-brown, the lower cells paler, sessile.

***Phakopsora Randiae* sp. nov.**

Pycnidiis et aecidiis ignotis.

Uredosoris hypophyllis, sparsis, rotundatis, parvis, punctiformibus, 0.1-0.2 mm. diam., flavis, subepidermalibus; paraphysisibus sorum circumdantibus, numerosis, plus minusve clavatis,  $7-13 \times 29-42 \mu$ , hyalinis; tunica convexo latere  $3-4 \mu$  incrassata; uredosporis subglobosis vel obovoideis,  $16-21 \times 19-26 \mu$ ; tunica hyalina,  $1-1.5 \mu$  cr., moderate echinulata; poris obscuris.

Teleutosporis hypophyllis, sparsis vel laxe gregatis, in maculis flavis subinde uredosoros circumdantibus, rotundatis vel irregularibus, 0.1-0.5 mm. diam., saepe confluentibus, epidermide tectis, nigro-brunneis; teleutosporis 2-6 superpositis, oblongis, cubicis vel plus minusve ellipsoideis,  $10-15 \times 16-32 \mu$ ; tunica  $1-1.5 \mu$  cr., superioribus ad apicem crassioribus,  $3-7 \mu$ , castaneo-brunneis, inferioribus pallidioribus.

On *Randia armata* (Sw.) DC. Túcupe, near Caracas, Dist. Federal, Feb. 28, 1939, Whetzel & Müller 2842; *Randia caracasana* Standl. Túcupe, near Caracas, Dist. Federal, Feb. 28, 1939, Whetzel & Müller 2852.

The punctiform uredinia opening by a central pore are typical. The dark telia are well developed, numerous, and fairly conspicuous. The telia may develop independently and are often separated from the uredinia.

***Prospodium aragatum* sp. nov.**

Pycnidiis et aecidiis ignotis.

Uredosoris hypophyllis, sparsis, in maculis decoloratis insidentibus, cinnamomeo-brunneis, rotundatis vel irregularibus, 0.3–0.5 mm. diam., subepidermalibus, epidermide rupta conspicua; uredosporis asymmetricis, globosis vel late ellipsoideis,  $26\text{--}35 \times 29\text{--}35 \mu$ , vel ellipsoideis,  $19\text{--}22 \times 20\text{--}35 \mu$ ; tunica bilaminata, interiore cinnamomeo-brunnea,  $2.5\text{--}3.5 \mu$  cr., exteriori hyalina tumescente et valide aculeata,  $3\text{--}5 \mu$ , supra poros 2 aequatoriales deficiente.

Teleutosoris hypophyllis, sparsis vel in greges parvos in maculis decoloratis dispositis, cacao-brunneis, ellipticis vel irregularibus, subinde confluentibus; 0.3–0.7 mm. diam., epidermide rupta conspicua; teleutosporis late ellipsoideis,  $27\text{--}32 \times 37\text{--}43 \mu$ , ad septum non constrictis; tunica bilaminata,  $2.5\text{--}3.5 \mu$  cr., interiore castaneo-brunnea, exteriori brunneola, moderate papillato-echinulata; poro cellulae superioris apicali, poro cellulae inferioris ad pedicelli insertionem sito, utroque poro unbone hyalino tecto; pedicello sporam aequante vel dimidio superante, hyalino, in tertia parte inferiore appendicibus 2–4 ramosis et verticillatis praedito.

On Bignoniaceae (*Tabebuia*?). Road Maracay a Guigue, Est. Aragua, April 5, 1939, Chardon, Whetzel & Müller 3327.

The specimen consists of two large leaves, or leaflets. The host is, therefore, unidentifiable but it seems likely to belong to Bignoniaceae, possibly a species of *Tabebuia*. The rust obviously belongs to the section *Euprospodium* of the genus *Prospodium*. The combination of characters differs from any of the species in Cummins's monograph (*Lloydia* 3: 1–78. 1940.).

***Prospodium Cumminsii* sp. nov.**

Pycnidiis epiphyllis, rubro- vel aurato-brunneis, subcuticularibus, lenti-formibus vel conicis,  $90\text{--}115 \mu$  altis,  $185\text{--}265 \mu$  latis, periphysibus praeditis.

Aecidiis amphigenis vel plerumque hypophyllis, in greges  $130\text{--}350 \mu$  diam. dispositis, plus minusve confluentibus, flavo-brunneis, apparenter subcuticularibus, uredinoideis; paraphysibus paucis vel carentibus; aecidiosporis late ellipsoideis vel globoideis,  $22\text{--}27 \times 25\text{--}29 \mu$ ; tunica flavida vel aurato-brunnea,  $2.5\text{--}3 \mu$  cr., aculeata, spinis  $2.5\text{--}3.5 \mu$  longis; poris 2, aequatorialibus, utroque poro umbone humiliter cuticulari tecto.

Uredosoris non visis, probabiliter teleutosoris conformibus; uredosporis probabiliter aecidiosporis conformibus.

Teleutosoris hypophyllis, sparsis, aecidiis propinquis, flavido-brunneis, per stomata erumpentibus, cyathiformibus,  $38\text{--}55 \mu$  diam.,  $53\text{--}65 \mu$  altis; stipite subhyalino; peridio aurato- vel cinnamomeo-brunneo, paraphysibus

periphericis, incurvatis, peridio concolorato,  $7-9 \times 36-43 \mu$ , plerumque ad apicem acuminatis; tunica convexo latere  $1.5-2 \mu$  cr., concavo  $2-3.5 \mu$ , ad apicem  $3-7 \mu$ ; teleutosporis ellipsoideis,  $23-25 \times 34-38 \mu$ , supra et infra rotundatis, ad septum constrictis; tunica cinnamomeo- vel pallide castaneo-brunnea,  $1-1.5 \mu$  cr., levi; poro cellulae superioris apicali, cellulae inferioris ad pedicelli insertionem sito, utroque poro umbone humiliter cuticulari tecto; pedicello persistenti, flavido vel pallide aurato-brunneo, cylindraceo, inornato,  $7-10 \mu$  lato, longissimo, usque ad  $350 \mu$  longo, tunica crassa; teleutosporis maturis statim germinantibus.

On *Amphilophium paniculatum* var. *molle* (S. & C.) Standl. El Junquito, road to Colonia Tovar, Est. Miranda, July 24, 1938, C. E. Chardon 2747 bis.

In 1940 Dr. G. B. Cummins published a splendid monograph of the genus *Prospodium* (Lloydia 3: 1-78.). This specimen was submitted to him and we are indebted to him for notes and measurements upon which the diagnosis is based. He has also supplied drawings and a photograph. As a tribute to his contribution to the knowledge of the genus and because of his aid in characterizing this species, we are pleased to dedicate the species to Dr. Cummins.

The species belongs to the section *Cyathopsora* and is unique and distinct, particularly in the very long teliospore pedicels which are without appendages.

It is interesting that this is the same collection (No. 2747) upon which *Prospodium depallens* is being reported. The host appears very similar to other mycological collections determined as *Pithecoctenium echinatum*. Our collection has been determined as *Amphilophium paniculatum* var. *molle* by Dr. E. P. Killip.

PROSPODIUM DEPALLENS (Arth. & Holw.) Cummins, Lloydia 3: 62. 1940.

On *Amphilophium paniculatum* var. *molle* (S. & C.) Standl. El Junquito, road to Colonia Tovar, Est. Miranda, July 24, 1938, C. E. Chardon 2747.

A most interesting microcyclic species; pycnia are present and the teliospores are germinated. The oblique septum and the presence of a hyaline plug over the germ-pores are conspicuous characters. There are no appendages on the pedicles but Cummins refers the species to *Prospodium* because of the presence of basal cells in the telia. The species is heretofore known only from Costa Rica and Guatemala.

This specimen has been examined by Dr. E. P. Killip, who determined the host as here recorded. It resembles and is closely related to *Pithecoctenium echinatum*, on which this rust has heretofore been reported.

*PUCCINIA AEGOPOGONIS* Arth. & Holw.; Arth., Am. Jour. Bot. 5: 467. 1918.

On *Eupatorium iresinoides* H.B.K. El Encantado, Est. Miranda, Aug. 6, 1937, *G. Vivas-Berthier* 2756.

This specimen differs from the description of the aecia of *Puccinia Aegopogonis* somewhat in habit and also in having aeciospore-walls frequently considerably thicker above. There must be some doubt whether this specimen really belongs here. The telial stage is on *Aegopogon* and is known to occur in Guatemala, Bolivia, and Ecuador. The aecia are otherwise known only from Guatemala.

***Puccinia Chaetii* sp. nov.**

Uredosoris (amphisoris) amphigenis, sparsis, oblongis, 0.2–0.8 mm. longis, obscure cinnamomeo-brunneis vel castaneo-brunneis, epidermide rupta conspicua; amphisoris globosis vel late ellipsoideis, 26–29 × 29–35  $\mu$ ; tunica cinnamomeo- vel pallide castaneo-brunnea, 2.5–3  $\mu$  cr., minute echinulata; poris plerumque 3, interdum leniter subaequatorialibus; pedicello plerumque persistenti, hyalino, sporam aequante vel brevior. Uredosporis immixtis, paucis, late ellipsoideis, 17–23 × 23–29  $\mu$ ; tunica pallide cinnamomeo-brunnea, 1–1.5  $\mu$  cr., echinulata; poris 3, aequatorialibus vel subaequatorialibus.

Teleutosoris amphigenis, sparsis, 0.3–1 mm., longis, atris, epidermide diu tectis; teleutosporis oblongo-ellipsoideis vel oblongo-clavatis, subinde angularibus, 18–26 × 39–44  $\mu$ , plerumque supra late rotundatis, infra contractis, ad septum leniter constrictis; tunica fragili, 1–1.5  $\mu$ , ad apicem leniter incrassata, pallide cinnamomeo-brunnea, infra pallidiore, levi; pedicello flavido, brevi, subinde oblique inserto.

On *Chaetium festucoides* Nees. El Sombrero, Est. Guarico, Dec. 5, 1939, *C. E. Chardon* 3885.

We have not found any rust on the tribe Paniceae like this. It is perhaps nearest to *Puccinia dolosa* Arth. & Fromme. A good description of the latter has been given by Dr. Cummins in *Mycologia* 34: 681. 1942. Our species differs in having slightly larger teliospores and in the urediniospores which are globoid or obovoid and not triangular as in *P. dolosa*. The dominant urediniospores in the new species are without doubt amphispores, which are char-

acterized by thick walls and pores which are definitely subequatorial. Sometimes one pore is near the septum.

*PUCCINIA CLAVIFORMIS* Lagerh., Tromsø Mus. Aarch 17: 53. 1917.

On *Solanum* sp. Road Maracay a Guigue, Est. Aragua, March 31, 1939, *Whetzel, Müller & Chardon* 3252.

Previously reported from Colombia and Panama.

*PUCCINIA EUPATORII-COLUMBIANI* Mayor, Mem. Soc. Neuch. Sci. Nat. 5: 514. 1913.

On *Eupatorium* sp. Rancho Grande, Road Maracay, Est. Aragua, March 25, 1939, *Chardon & Whetzel* 3119.

Heretofore reported from Colombia, Brazil, Bolivia, and Trinidad.

*PUCCINIA GLUMARUM* (Schmidt) Erikss. & Henn., Zeits. Pflanzenkr. 4: 197. 1894.

On *Triticum aestivum* L. Mucuchies, Est. Merida, Nov. 6, 1940, *N. Castillo & A. S. Müller* 3932.

### *Puccinia Hilleriae* sp. nov.

Pycnidiis amphigenis, paucis, in areis hypertrophicis insidentibus, subepidermalibus, profunde insitis, atro-brunneis, ellipsoideis, 96–144  $\mu$  latis, 144–180  $\mu$  altis; periphysibus non visis.

Aecidiis amphigenis, in greges crebres 0.5–3 mm. dispositis plerumque areas hypertrophicas ad nervos efficientibus, flavidis, bullatis, 0.2–0.3 mm., poro apertis; peridio nullo; aecidiosporis ellipsoideis vel ellipsoideo-obovoideis, 18–23  $\times$  34–42  $\mu$ , catenulatis; tunica pallide flavida vel subhyalina, ca. 2  $\mu$  cr., saepe supra et infra usque ad 5  $\mu$  incrassata, conspicue et sparse echinulata; poris obscuris, verisimiliter 1 vel 2 aequatorialibus.

Teleutosoris amphigenis, sparis vel interdum gregariis, rotundatis vel irregularibus, interdum punctiformibus, 0.1–0.2 m. diam., mox nudis, castaneo-brunneis, pulverulentis, epidermide rupta conspicua; teleutosporis late ellipsoideis, 21–26  $\times$  30–42  $\mu$ , supra et infra rotundatis, vix vel non constrictis; tunica castaneo-brunnea, 1.5–2  $\mu$ , apice non incrassata, moderate verrucosa; poro cellulae superioris apicali vel leniter laterali, inferioris laterali; pedicello fragili, hyalino.

On *Hillera secunda* (R. & P.) H. Walt. Road La Guaira a Caracas, March 3, 1939, *Müller & Whetzel* 2929.

This species presents an interesting combination of characters. Pycnia, aecia, and telia are present. The telia fit the well estab-

lished genus *Puccinia*. The aecia are unusual in being without a peridium but with aeciospores which are catenulate and with echinulate markings on the walls. There are species lacking a peridium with catenulate spores but usually the markings are verrucose. When aeciospores are echinulate they are usually borne singly on pedicels. We are indebted to Dr. Cummins for calling attention to *Puccinia morobensis* described by him on *Tabernaemontana* from New Guinea. This has somewhat similar characteristics in that the aecia are without peridium and the aeciospores have walls which are not verrucose but aculeate. There may be other species with these exceptional characters but they appear to be rare.

<sup>2</sup> *PUCCINIA HOLWAYULA* Jackson, *Mycologia* 24: 163. 1932.

Further study of specimens referred to this species, and to *Puccinia Oyedaeae* Mayor, in an earlier paper (Monog. Univ. Puerto Rico, Ser. B. No. 2, Uredinales, p. 280 and p. 284, 1934), reveals additional facts which should be reported. In the first place we now feel sure that the specimen, Sydow 28, on *Oyedaea verbesinoides* referred doubtfully to *Puccinia Oyedaeae*, is not that species at all but rather *Puccinia Holwayula*. We are now agreed that *Puccinia Oyedaeae* is not known from Venezuela. Since it was described from Colombia, there is reason to think that it may occur in Venezuela, but we have not yet found any specimens of it among those we have studied. In the second place we reported *Puccinia Holwayula* doubtfully on *Wedelia Jacquinii caracasana* (D.C.) O. F. Schultz, Chardon, Toro & Alamo 308 and Chardon & Toro 455. We are convinced that the hosts of these two collections are a species of *Oyedaea*, probably *O. verbesinoides*. We now have two additional specimens from Venezuela which we are referring to this species, both undoubtedly on *O. verbesinoides*, collected Caracas a Colonia Tovar, Dist. Federal, March 17, 1939, Whetzel & Müller 2994 and 3002.

*Puccinia Holwayula* is characterized by epiphyllous aecia, aeciospores with verrucose-tuberculate walls, and thick-walled urediniospores with coarsely verrucose-echinulate walls and scattered pores.

<sup>2</sup> This species is not an addition to the Venezuelan list; it was reported in 1934.

PUCCINIA HYPTIDIS (Curt.) Tracy & Earle, Bull. Miss. Exp. Sta. 34: 86. 1895.

On *Hyptis capitata* Jacq. Rancho Grande, Road Maracay a Ocumare de la Costa, Est. Aragua, March 28, 1939, Whetzel & Chardon 3187.

Known from southeastern United States, West Indies, Trinidad, Colombia, British Guiana, and Bolivia.

PUCCINIA IMPEDITA Mains & Holw.; Arth., Mycologia 10: 135. 1918.

On *Salvia* aff. *coccinea* Juss. Paramo La Negra, Est. Tachira, Nov. 17, 1939, Barrus & Müller 3591.

This species is well known in the West Indies and Central America. Jackson (Mycologia 24: 76. 1932.) has reported it from Bolivia. It is also known in Trinidad.

***Puccinia Mirandensis* sp. nov.**

Uredosoris hypophyllis, sparsis, ellipticis vel oblongis, 0.2–0.5 mm. longis, epidermide diu tectis, cinamomeo-brunneis; uredosporis ellipsoideis vel obovoideis, 19–26 × 29–35  $\mu$ ; tunica flavida vel pallide cinnamomeo-brunnea, 1–1.5  $\mu$  cr., moderate echinulata; poris 3 aequatorialibus.

Teleutosoris hypophyllis, sparis, ellipticis vel oblongis, 0.2–0.7 mm. longis, nigrescentibus, tarde nudis, epidermide rupta conspicua; teleutosporis cylindraceis vel clavatis, 12–21 × 55–87  $\mu$ , supra rotundatis vel obtusis vel truncatis, infra contractis, vix vel non constrictis; tunica pallide castaneo-brunnea vel infra pallidiore, ca. 1.5  $\mu$  cr., apice incrassata, 5–10  $\mu$ , levi; pedicello tincto, brevi, 12–16  $\mu$  longo.

On *Scleria secans* Urban. Road Petare a Santa Lucia, Est. Miranda, April 13, 1939, Whetzel & Müller 3400.

There are two species of *Puccinia* known on *Scleria*, *Puccinia Scleriae* (Paz.) Arth. and *Puccinia scleriicola* Arth. Our species differs from both of these in the larger size of the spores, both urediniospores and teliospores. It differs further from *Puccinia Scleriae* in not having biseptate teliospores.

PUCCINIA OFFUSCATA Arth., Bull. Torrey Club 47: 469. 1920.

On *Zornia diphylla* (L.) Pers. San Cristobal, Est. Tachira, Nov. 15, 1939, Barrus & Müller 3599.

Previously known from Florida, the West Indies, Brazil, and Bolivia.

PUCCINIA SOLANI-TRISTIS P. Henn., Hedwigia 35: 236. 1896.

On *Solanum* sp. Highway, Hacienda Moron, Est. Carabobo, April 3, 1939, *Whetzel, Müller & Chardon* 3310.

This microcytic species is characterized by comparatively small teliospores with fairly thin yellowish or colorless walls. It has heretofore been reported only from Brazil.

RAVENELIA INDICA Berk., Gard. Chron. 1853: 132. 1853.

On *Cassia Absus* L. El Tigre, Est. Anzoategui, Sept. 29, 1939, *A. S. Müller* 3487.

Previously known from India, Mexico, and Cuba.

UREDIO ALCHORNEAE P. Henn., Hedwigia 35: 252. 1896.

On *Alchornea triplinervia* (Spreng.) Muell. Arg. Caracas a Colonia Tovar, Dist. Federal, March 19, 1939, *Whetzel, Müller, & Tamayo* 3046.

Our rust agrees perfectly with the description given by Sydow (Monog. Ured. 4: 457. 1924.) which is based on a specimen from Tubarao, Prov. St. Catherina Brazil. So far as known to us this is the first report outside the type locality.

UREDIO ERYTHRINAE P. Henn., Ann. Mus. du Congo 2: 224. 1908.

On *Erythrina glauca* Willd. Gorge Road, Maracay a Guigue, Est. Aragua, March 31, 1939, *Chardon, Whetzel & Müller* 3238.

This species was originally described from the Congo. It has since been reported from Ceylon, the Philippines, Guatemala, and Ecuador. It is characterized by the small sori, numerous paraphyses, and small colorless spores.

#### *Uredo paraphysata* sp. nov.

*Uredosoris amphigenis*, sparsis vel in greges parvos collectis, in maculis decoloratis dispositis, rotundatis, 0.1–0.3 mm. diam., mox nudis, pulverulentis, cinnamomeo-brunneis, epidermide rupta non conspicua; paraphysibus numerosis, clavatis vel clavato-capitatis, plus minusve incurvatis, 13–15 × 48–64  $\mu$ ; tunica infra pallide, tenui, supra castaneo-brunnea vel pallidiore, 2–3  $\mu$  incrassata; uredosporis late ellipsoideis, 19–24 × 24–29  $\mu$ ; tunica cinnamomeo-brunnea, 1–1.5  $\mu$  cr., valde echinulata; poris 2 aequatorialibus.

On *Oliganthus* (?) *hypochlora* Blake. Caracas a Colonia Tovar, Dist. Federal, March 17, 1939, *Whetzel & Müller* 3000.



An interesting species because of the characteristic paraphyses with their brownish, thickened tips. The host doubtless belongs to the genus *Oliganthes* and Dr. S. F. Blake thinks it probably *O. hypochlora*. The genus is closely related to *Vernonia*. In fact some of the leaves of this collection bear sori of *Puccinia rotundata* Diet. which has been known previously only on *Vernonia*. Our *Uredo* does not, however, match any of the *Vernonia* rusts known to us.

***Uredo Pehriae* sp. nov.**

Uredosoris hypophyllis, sparsis vel laxe gregariis, parvis, ca. 0.1 mm., diam., cinnamomeo-brunneis, mox nudis, pulverulentis, epidernide rupta conspicua; uredosporis late ellipsoideis vel obovoideis, saepe leniter angularibus,  $16-23 \times 24-29 \mu$ ; tunica cinnamomeo-brunnea,  $1-1.5 \mu$  cr., moderate echinulata; poris 2-3, aequatorialibus vel super-aequatorialibus.

On *Pehria compacta* (Rusby) Sprague. Chirgua, Est. Carabobo, Dec. 15, 1939, *M. F. Barrus* 3698.

Several species of *Uredo* have been described on hosts of the family Lythraceae. The best known one is *Uredo Cupheae*. Our species differs from that in habit, having much smaller sori. Jackson has described *Uredo cupheicola* which differs in the larger spores. *Uredo Lafoenseae*, also described by Jackson, is similar but has larger sori and minor differences in the spore characters. It must be admitted that the four species have many characters in common.

In addition to the specimen cited we have found scant uredinia on two collections of *Accidium Adenariae* on *Adenaria floribunda*, both from Medellin, Colombia. There is a possibility that *Uredo Pehriae* and *Accidium Adenariae* may be stages in the life history of the same species.

UREDIO RHOMBICA Speg. Anal. Soc. Ci. Argent. 17: 124. 1884.

On *Astronium graveolens* Jacq. Road Maracay a Guigüe, Est. Aragua, April 5, 1939, *Chardon, Whetzel & Müller* 3322.

Our specimen agrees with the description of *Uredo rhombica* in the characteristic rhomboid urediniospores, except that the spores are somewhat smaller. It has been reported previously from Paraguay and Brazil.

UROMYCES CISNEROANUS Speg., Anal. Soc. Ci. Argent. 10: 134. 1880.

On *Sapium* sp. Rancho Grande, Road Maracay a Ocumare, Est. Aragua, March 29, 1939, Chardon, Whetzel & Müller 3213.

This specimen consists of the lower half of a leaf with a note that it had fallen from a tall tree. The teliospores agree so well with a Spegazzini specimen (No. 17, Dec. Myc. Argentinae) that there can be no doubt about its identity. The host is a different species of *Sapium*. The rust has been previously reported from Argentina, Paraguay, and Brazil.

UROMYCES VIGNAE Barclay, Jour. Asiat. Soc. Bengal 60: 211. 1891.

On *Vigna luteola* (Jacq.) Benth. Caracas, Dist. Federal, July 20, 1938, A. S. Müller 2181, July 28, 1938, A. S. Müller 2182.

Only urediniospores are present. They agree with the characterization of this species as set forth by Fromme (Phytopath. 14: 67-79. 1924.), especially in the two pores which are evident and superequatorial. This species is similar to *Uromyces appendiculatus* but the latter has 2-3 obscure, equatorial pores. *Uromyces Vignae* is a cosmopolitan species. It has not been previously reported from Venezuela.

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# LIFE HISTORY OF CERCOSPORA ON SWEETCLOVER<sup>1</sup>

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## INTRODUCTION

One of the most common and easily recognized of the leafspots of sweetclover is caused by a species of *Cercospora*. An equally common, but less frequently distinguished stem blackening of cultivated sweetclover is caused by the same fungus. On overwintered stems of sweetclover a species of *Mycosphaerella* was found in 1937 which gave cultures of *Cercospora* indistinguishable from those obtained from conidia of this fungus, and later the spermogonial stage of this fungus was found. The evidence which links the three forms of this fungus is here presented.

## OCCURRENCE OF CERCOSPORA ON SWEETCLOVER

Well developed spots caused by *Cercospora* are found chiefly on older leaves of sweetclover. These spots are usually few, circular, ashy gray to tawny or have black centers when conidiophores are abundant. Infected leaves soon shrivel and drop. On stems the fungus produces discolorations differing greatly with the age and maturity of the stem. On stems of the first year's growth reddish brown lesions somewhat zonate or with diffuse edges often develop in autumn after frost. The fungus can often be isolated from stems which show only tiny discolored flecks. On growth of the second year the fungus usually becomes conspicuous when the plants are about to blossom. It is often found early on stems which are dying back after having been cut or grazed. On such stems it may fruit abundantly in wet weather. Thick stands forced to early maturity by insufficient moisture sometimes be-

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come heavily infested so that the stems turn black, and after a dewy night these stems may have in early morning a discernable white sheen from the quantity of conidia produced. Pedicels become infected, maturing seed may fall prematurely, and the seed itself may be penetrated and carry the fungus (5). The fungus varies greatly in abundance from year to year. Carver (1) in 1901 reported *C. Davisii* as being destructive to foliage of sweetclover (*M. alba*) in Mason County, Alabama. This fungus often occurs in association with *Mycosphaerella lethalis* Stone, the so-called black stem fungus, which causes a somewhat similar discoloration of stems. Stem blackening from *Cercospora* and other fungi is usually found much more severe in second year's growth that has been clipped or grazed than in stands which make their complete growth without defoliation.

#### THE CONIDIAL STAGE

*Cercospora* on sweetclover appears to be recorded in Europe under the name *C. Meliloti* Oud. (2, p. 23), the oldest name given to a species in this genus on *Melilotus*. *Cercospora* was first described on *Melilotus alba* in the United States under the name *C. Davisii* Ellis & Ev. (3). Horsfall (4) has concluded on the basis of excellent evidence in the literature—no European collection being available—that the fungus is not that described by Oudemans. Furthermore, Horsfall (l. c.) concluded on the basis of evidence from herbarium material that only one morphological species in the genus *Cercospora* occurs on species of *Trifolium*, *Medicago* and *Melilotus*, and that the oldest name, *C. zebrina* Pass. should be used for it. This usage has been generally followed. Later Nagel (7) made inoculation with *Cercospora* from *Melilotus* on 16 species in the genera *Medicago*, *Trifolium* and on *Melilotus alba* and infected only *Melilotus alba*. Thus it appears that this evidence of the specificity of the *Cercospora* on *Melilotus* together with the following evidence of a distinct life history provide good reason for retaining the name *C. Davisii* for this fungus.

#### THE SPERMOGONIAL STAGE

In autumn small pycnidia with minute spores that appear to be spermatia often appear abundantly on blackened stems that have

borne the conidial stage earlier. None of these have been found upon leaves. At first they overflow with many spermatia, but in late fall they may be quite empty. The spermatia have not been germinated. This stage of the fungus has been cultured only by lifting the tiny structure out of the stem tissue with a needle under a binocular and transferring it to an agar substratum. When this has been done in late autumn after the stems have weathered a little these structures send out mycelium of *Cercospora* alone in a majority of the transplants.

Further evidence that these structures developed from the mycelium of *Cercospora* was obtained as follows. When it was found that they did not develop on stems inoculated in a warm greenhouse, and appeared in the field only after the arrival of cool weather, pieces of infected stems of greenhouse plants were incubated in a series of chambers held at temperatures from 8 to 32 degrees C. with 4 degree intervals. At temperatures from 8 to 16 degrees these spermogonia developed in from 3 to 4 days at 16 degrees and in about 10 days at 8 degrees. At 20 degrees and above only conidia of *Cercospora* were produced on the stems, while at 16 degrees and below only a few conidia were produced along with spermogonia. Stems from the field blackened by *Cercospora* were found to produce spermogonia when placed at the temperature range indicated above long before these structures appeared in the field. Thus their development appears to be conditioned by temperature. The fact that these spermogonia develop on inoculated plants which appear to be free from other fungi under the same conditions that favor their appearance in the field is taken as strong supporting evidence that they belong in the life cycle of the fungus. The spermogonia have not developed in pure culture even upon *Melilotus* stems, however.

The precise development of the spermatia has not been traced in cytological preparations. The development of the spermogonia has been observed on inoculated stems after they have dried for at least two months in the greenhouse and where little contamination from other fungi was found. From this, it appears that the spermatia develop in the manner described by Wolf for *Cercospora sordida* Sacc. (10) or by Jenkins for *Cercospora arachidicola* Hori (6). On the bleached stems incubated in a moist

chamber the stromata giving rise to the spermogonia are quite hyaline and the surrounding wall is poorly developed, and may occasionally grow out as conidiophores from which conidia are developed, especially if the temperature is raised after spermogonia are initiated. Thus it appears possible that conidia might develop from overwintered mycelium to perpetuate the fungus in the failure of the ascigerous stage, though this has not been observed in the field.

It appears more probable that such overwintering occurs with the *Cercospora* on alfalfa, where stems blackened by the fungus have been searched in vain for any evidence of a following spermogonial or ascigerous stage, either in the field, or when such stems have been incubated at temperatures at which the spermogonial stage appears upon sweetclover.

#### THE ASCIGEROUS STAGE

The perithecial stage of this fungus has been found to differ greatly in abundance from year to year since it was first found in the autumn of 1937. In 1938 none of it was discovered. When it occurs it is often so mixed with other ascomycetes which are abundant on sweetclover stems that good material for the herbarium cannot be separated, and it has often been identified by culture from groups of ascospores discharged from scattered perithecia upon agar. It seems probable that the development of the perithecial stage is conditioned by suitable rainfall when the spermogonia develop, as in the case of *Mycosphaerella arachidicola* W. A. Jenkins upon peanut (6 p. 322), and that this dependence upon climate may account for its fluctuations in abundance. Since the perithecia are inconspicuous in the tissue of the stem and can hardly be distinguished by outward appearance from those of other species often present on stems, their presence is best determined by placing moistened strips of bark over plates of clear agar and searching the agar for characteristic spores.

Mature perithecia are found at Madison, Wisconsin, about the first of June, and spores may be discharged more or less abundantly during the entire summer. No previous description has been found of this highly inconspicuous stage of the fungus.

## CULTURAL CHARACTERS

The cultural characters of this fungus have been so well described by Nagel (8) and of similar species by Jenkins (6) that little new information can be added. The fungus grows on common culture media, and the chief problem encountered has been in inducing the formation of conidia. Nagel's experience (l.c.) that the best culture medium for conidial production should have only so much agar in it as was necessary to allow the inversion of plates without having the agar flow was corroborated. When such agar was used conidial production was obtained in transfers even from old dried cultures. Such cultures were macerated in a little water, which was poured over an agar plate, and after the debris had settled, the surplus water was poured off. In 3 or 4 days when a few conidia began to appear they were washed from this plate with a little sterile water and poured over a new agar plate where conidia usually became abundant. Old cultures of *Cercospora* from sweetclover, red clover and alfalfa responded to this treatment but one culture from *Medicago lupulina* did not. Inoculation was often conveniently made by touching leaves to the surface of a spore bearing plate.

## INOCULATION EXPERIMENTS

Inoculation trials were made in the usual manner and thus need not be described in detail. Infection was always far more successful in the older leaves of plants and on the stems of second year growth of sweet clover after blossoming had begun. In fact, no visibly successful infection of first year stems was made in the greenhouse. From isolations in the field it is known that such stems are infected, though perhaps rarely or never with the fruiting of the fungus. Lesions developed far more abundantly and rapidly in plants placed in a moist chamber over night from time to time after the original inoculation than in those which remained in the greenhouse.

Inoculations have been made with cultures of *Cercospora* from sweetclover, alfalfa and red clover upon all three of the hosts, but infection has been obtained only upon the host from which the culture was derived. Thus pending a satisfactory account of the

life histories of the *Cercosporas* on alfalfa and red clover it appears more convenient to regard them as distinct species.

#### RESISTANCE TO STEM BLACKENING BY CERCOSPORA

Evidence of resistance to stem blackening by *Cercospora* has been sought by Dr. W. K. Smith and the writer in the former's breeding nursery containing hundreds of selections of both *Melilotus alba* and *M. officinalis*. Differences in stem blackening in early summer are often found to be correlated with the maturity of the strains compared, and appear to represent only the commonly observed correlation between maturity and infection mentioned previously. However, conspicuous instances of extreme blackening or failure to blacken have been found which persist, and do not appear to represent such correlations. Extreme and uniform resistance has been observed through two summers in selfed lines of *Melilotus alba* derived from three resistant plants selected by Dr. Smith in a planting from seed collected by Westover and Wellman in Turkey in 1936, and designated by the Foreign Plant Introduction number 120,048. The remarkable freedom from blackening in stems of these strains through two summers in which it has been observed may be taken as indicating that they are also resistant to the black stem fungus, *Mycosphaerella lethalis*.

#### TAXONOMY

A technical description of the fungus is presented herewith.

#### *Mycosphaerella Davisii* sp. nov.

Perithecia often few and scattered, inconspicuous on dead overwintered stems, developing beneath the epidermis through which the ostiole opens, spherical, dark in color, 70–100  $\mu$  in diameter. Asci cylindrical to club shaped, grouped at the base of the perithecia from which they appear to develop in succession for a long period in the summer, eight spored, without paraphyses 40–60  $\times$  10  $\mu$ . Ascospores irregularly biseriate with median septa, hyaline, straight along one side or slightly curved, and bluntly pointed at the ends, 12–20  $\times$  4–5  $\mu$ .

Spermogonia developing in late summer and autumn on mature and dying stems only, thickly scattered, especially at the margins of lesions, black, subepidermal, erumpent, often flattened and ap-



proaching an acervulus in form, with ostiole variable in size, 80–120  $\mu$  in diameter. Spermatia rod shaped, about  $1\frac{1}{2}$ –3  $\times$  1  $\mu$ .

The original description of the conidial stage, *Cercospora Davisii* Ellis & Ev. has been emended by Solheim (9) as follows.

“Spots amphigenous, subcircular, more or less vein limited, at times confluent, 1–5 mm., greenish yellow to dark brown; border indefinite or in part definite, slightly raised, yellowish-brown, 1.5–4.5  $\mu$ . Conidiophores amphigenous, loosely or somewhat densely tufted, emerging through the stomata or rupturing the epidermis, simple, straight to subflexuous, with or without a bulbous base, arising from a stroma of loosely to fairly compactly woven hyphae; pale dresden brown, 20–85  $\times$  3–6  $\mu$ ; continuous or 1–2 septate above bases; conidial scars distinct, shouldered, mostly aggregated towards the tips. Conidia at first cylindrical, then acicular, subhyaline to light greenish yellow, 20–140  $\times$  2.2–4.5  $\times$  1.2–2.5  $\mu$ , at first continuous, becoming closely 1–13 septate.”

On leaves and stems of *Melilotus alba* and *M. officinalis*. Type collections of the ascigerous and spermogonial stages have been deposited with the Mycological Collections of the Bureau of Plant Industry of the U. S. Dept. of Agriculture, and in the Herbarium of the University of Wisconsin.

Perithecis in caulibus mortuis saepe sparsis, immersis, erumpentibus, globosis, 70–100  $\mu$ , nigris, ostiolatis; ascis cylindraceis vel clavatis, brevissime stipitatis, aparaphysatis, fasciculatis, octosporis, 40–60  $\times$  10  $\mu$ ; sporidiis subbiseriatis, bicellularibus, hyalinis, curvulis, 12–20  $\times$  4–5  $\mu$ ; spermogoniis autumnino in caulibus maturissimis efformatis, plerumque ad macularum margines, nigris, saepe ostiolis latis et irregularibus, 80–100  $\mu$ ; spermatiiis bacillaribus, hyalinis, 1.5–3  $\times$  1  $\mu$ . Statu conidico *Cercospora davisii* Ell. et Ev.: maculis in foliis amphigenis, fuligineo-brunneis, orbicularibus, in caulibus emortuis elongatis, indefinitis, confluentibus, atro-brunneis vel nigris; hyphis amphigenis, rufescentibus, rectis, fasciculatis vel singularibus, e stromate delimitato oriundis, geniculatis, continuis, deinceps septatis, 20–80  $\times$  3–5  $\mu$ ; conidiis hyalinis usque viridiflavidulis, cylindrico-acicularibus, multiseptatis, 20–140  $\times$  3–6  $\mu$ .

Hab. in foliis caulibusque *Meliloti* spp. (U. S.).

#### SUMMARY

The life history of *Cercospora Davisii* Ellis & Ev. on *Melilotus* spp. appears to have been completed by the finding of the spermogonial and the ascigerous stage. The development of the spermogonial stage appears to be dependent upon a temperature below 20

degrees C. The asexual stage found on overwintered stems is described as *Mycosphaerella Davisii*. Evidence of resistance to stem blackening by this fungus is recorded.

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## ON THE DATES OF PUBLICATION OF SCHWEINITZ'S SYNOPSES

DONALD P. ROGERS

The first paper on American fungi, the "Synopsis fungorum Carolinae Superioris secundum observationes Ludovici Davidis de Schweinitz," was published in the first (and only) volume of the *Schriften der naturforschenden Gesellschaft zu Leipzig*. That volume bears on its title-page the date 1822, and that year has in consequence usually been taken as the year of publication of Schweinitz's work. By some authors, however (e.g., Pennell, *Bartonia* 16: 4. 1934 (but see also his footnote 5); Kellerman, *Jour. Myc.* 2: 31-34. 1886; Johnson, A memoir of the late Lewis David von Schweinitz, P.D. Phila. 1835), the year has been given as 1818—perhaps in part because the manuscript was "laid before the Gesellschaft" on December 7, 1818 (*Naturf. Ges. Leipzig Schr.* 1: 212. 1822). Furthermore, the possibility has existed that separate copies of Schweinitz's work were issued in advance of the publication of the complete volume, and might therefore have a separate date. If Schweinitz's paper was published before 1821, it of course falls under the deadly obloquy of being pre-Friesian. Furthermore, in 1822 there were published several important mycological works, whose relative dates seem not to have been established. It is therefore a matter of some importance to determine as accurately as possible the date of the "Synopsis," in order that the nomenclatorial status of that important paper may be known.

The article immediately preceding Schweinitz's in the complete volume of the *Schriften* was read March 14, 1820, as a memorial to a man who died February 29, 1820 (p. 12); a footnote (p. 16) refers to an article published March 25, 1820. Now the first page of the introduction to the Schweinitz article (p. 20) occupies the verso of the last page (p. 19) of that obituary notice, and must have been published with it; the two articles are as closely tied together as are Fitzpatrick's and Orton's in the current volume

of *Mycologia* (cf. *Mycologia* 36: 17, 18). From this alone, then, the earliest possible date for the publication of the "Synopsis" in the *Schriften* is one later than March 25, 1820.

The last page (p. 131) of the Schweinitz article occupies the recto of the leaf on which it is printed; on the verso of the same leaf (p. 132) begins a paper by Wellner; these two must also have been published together. Next, p. 139 of Wellner's paper is on the recto of the first page of a paper by Clarus. This paper by Clarus is marked (p. 140) as having been read April 10, 1821, a still later date to which the publication of the "Syn. Fung. Car." probably was not antecedent. The last page (p. 147) of Clarus's article occupies the recto of the first page of one by Cerutti; Cerutti's paper ends on p. 157 (recto), and the next paper, by Radius, begins on the verso of the same leaf (p. 158); Radius's article ends on p. 161 (recto), and one by Schmidel begins on p. 162 (verso). The latter deals with meteorological data for the entire twelve months of 1821, and consequently neither it nor the papers joined to it could have been published as parts of the *Schriften* before 1822. Schmidel's article ends on p. 174 (verso); since its pages 169-70 are conjugate (that is, continuous through the binding, and therefore printed on the same sheet, and simultaneously) with pp. 175-76 of the following article, by Müller & Kunze, it does not even so interrupt the series. This paper by Müller & Kunze is dated (p. 176) April 6, 1822—the latest date incontestably joined to Schweinitz's paper. Nevertheless, the concatenation of articles remains unbroken through the index, which ends on p. 232. That is, quite by chance no article is of such length as to fill up the gathering of eight pages which was printed at one time on one sheet of paper. Since there are no blank pages, it follows that at least through p. 232 the *Schriften* was printed and in all probability published as a unit, and that the date April 6, 1822, is tied to the Schweinitz paper by much more than the binding of the volume.

After the index there follows a set of day-by-day weather-tables for 1821, without pagination, and dated on the last page July 18, 1822. These tables, present in at least two copies of the *Schriften* (Farlow Library, and my own) are printed on the same paper and in the same styles of type as the rest of the volume, and appear

to be a part of it. Unfortunately, the chance that served to join together all the rest operated to separate this last article: the weather-tables begin on the first page of the gathering, and therefore may just possibly have been subsequently printed and—what is more important—subsequently dated. Next comes a table of contents, in which the unpagged weather-tables are set down as commencing on p. 233, and after that, the seven plates. Because the table of contents lists the weather-tables, it is quite probable that they, with their date of July 18, 1822, formed a part of the *Schriften* as issued; but that cannot be proved from the evidence at hand.

Since the volume of the *Schriften* is dated 1822, Schweinitz's "Synopsis" probably was not issued before that year unless it appeared as an advance separate. Now there does exist a separate issue of the "Synopsis." As is generally known, Schweinitz's paper was published by Schwaegrichen, the editor of the *Schriften*, from Schweinitz's manuscript but without his knowledge. For the *Schriften* Schwaegrichen wrote a long introduction (pp. 20-27) and commissioned an illustrator to prepare the two plates.<sup>1</sup> The separate issue lacks that introduction; in the place of its last page the separate carries a title-page different from the heading appearing (p. 20) in the *Schriften*. It differs also in pagination, its pages running from 2-105 instead of 28-131 (whence the pagination given in the separate can be corrected by adding 26 to the numbers printed at the head of its pages), and in the signatures, which run from B (on p. 7) to O (on p. 103), instead of from E to R. Irregularities in the type (e. g., broken *s* and *t* in *ostiolis*,

<sup>1</sup> Arthur (Amer. Naturalist 17: 77. 1883) and Shear & Stevens (Myco-logia 9: 195. 1917) have supposed that Schweinitz's "great microscope" was used in the preparation of the descriptions for the "Syn. Fung. Car." That would seem not to be the fact. In his letter to Torrey of June 24, 1820 (cf. Shear & Stevens, Torrey Club Mem. 16: 125. 1921), Schweinitz wrote "Since my return, having provided myself with instruments and books . . ."; and the implication is that he had provided himself with "instruments" only after his return from his European travels of 1817-18, during which he left the manuscript of the "Synopsis" with Schwaegrichen. In the introduction to the "Synopsis" Schwaegrichen wrote that he had added to Schweinitz's notes "description of the more minute parts, drawn up under a stronger microscope, of which the author himself was destitute, and illustrations . . ." (Naturf. Ges. Leipzig Schr. 1: 27. 1822).

p. 9, or p. 35, l. 23) are, however, the same in the separate copies (Farlow Library, Brown University library) as in the complete volume; and therefore, whatever alterations were made in pagination, the text was set in type but once. The question is then whether the "Synopsis" (a) was first set up and printed as a part of the *Schriften*, and afterwards reprinted, with page-numbers and signatures changed, or (b) was printed separately in advance, and afterwards altered so as to be incorporated in the *Schriften*. Now in the separate copy the article commences on the left-hand page, as in the complete volume; if it had first been printed in the separate form it would almost certainly have begun on the right-hand page. What is more, in the separate edition the first signature (B) is printed at the foot of p. 7, after only six pages (title-page and five pages of text), rather than after the full eight pages which normally would make up a gathering; it thus occupies the same position as signature E of the *Schriften*. The only explanation of these anomalies seems to be that the separate was printed from the same types as the complete volume without rearrangement of the forms. From this it follows that the forms were first assembled for the printing of the complete edition, and the separate is not an advance publication, but an extract. Furthermore, it follows from the evidence of the concatenation of the papers, and would be indicated by the signatures alone, that the *Schriften* was set up as a unit, and not as an assemblage of parts or numbers; it is not a periodical at all. It is equally apparent that it cannot have appeared as a completed volume before April 6, 1822, and if, as seems to be the case, the weather-tables and table of contents form a part, it cannot have appeared before July 18, 1822.

As must be the case with almost any volume ever printed, there is a possibility that the *Schriften* was issued, as well as printed, a gathering (or a few) at a time—even though each portion, of whatever size, must necessarily have been incomplete. If such a possibility be allowed, the "Synopsis" cannot be shown certainly to have been issued much later than March 25, 1820. But since more than half the volume must have been completed before the completion of the "Synopsis," and since the whole does not represent a very extensive job of printing, that possibility seems remote, and no more worth considering for this than for any coeval work.

So much for internal evidence. The earliest notice of either the *Schriften* or the "Syn. Fung. Car." seems to be that in a semi-annual *Verzeichnis neuer Bücher*. The volume of this publication for the first half of 1821 faithfully records the appearance of Fries's *Systema*, vol. I; that for the second half of the year lists the German edition of Persoon's *Traité sur les Champignons* (although the title-page of that edition is dated 1822); the volume for the first half of 1822 reports the publication of Persoon's *Mycologia europaea*, pt. I; but no Schweinitz. Finally on p. 96 of the *Verzeichnis neuer Bücher, die vom Juli bis Dezember 1822 wirklich erschienen sind* (J. Hinrichschen Buchhandlung . . . Leipzig, 1823) is listed the *Schriften*. Since the society which published Schweinitz's paper met, and published its Journal, in the city where the *Verzeichnisc* was published, there appears no reason to suppose a great delay in reporting its appearance. The *Schriften* was noticed, and Schweinitz's paper made the subject of an extensive critical review by Nees von Esenbeck, in *Flora* 6 (2): Beil. 65-86. 1823. It seems safe then to set the date of publication in the second half of 1822—later than the *Systema*, vol. I, later than Gray's *Natural Arrangement*, later than sect. I of the *Mycologia europaea*, probably later than July 18. It is earlier than vol. II (1) of Fries's *Systema*, in which the *Synopsis* is frequently cited (e. g., *S. M.* 2 (1): 12, under *Morchella patula*).

According to a letter from Schweinitz to Torrey published by Shear & Stevens (Torrey Club Mem. 16: 165. 1921), Schweinitz received copies of the "Synopsis" in time to send one to Torrey on November 24, 1822. Deduction of the estimated time required to bring the paper from Leipzig to Bethlehem would provide a fair approximation of the latest possible date of publication.

According to the decision of the Amsterdam Congress (Zesde Int. Bot. Congr. Proc. 1: 343-344), the date of publication of groups published both in advance separates and in a complete volume is the date *on* the separates, or of the journal. Since the "Syn. Fung. Car." as separately published carries no date, under that rule the groups published in it were published on the date of the whole volume, regardless of any possibility that separates were issued somewhat earlier.

The date of Schweinitz's "Synopsis Fungorum in America Boreali media degentium" is less critical than that of the earlier "Synopsis," has less often been incorrectly stated, and can be established with less difficulty. The "Syn. Fung. Am. Bor." was published in volume 4 of the new series of the Transactions of the American Philosophical Society. That volume bears on its title-page the year 1834; the article is marked (p. 141) as having been communicated to the society April 15, 1831; and both 1831 and 1834 have occasionally been given as the date for the Schweinitz paper. The series of letters published by Shear & Stevens, however, provides adequate information for determining the true date. On May 24, 1832, Schweinitz wrote to Torrey "that my Synopsis of American Fungi—is very nearly printed" (Torrey Club Mem. 16: 275. 1921). On July 29, 1832, the librarian of the American Philosophical Society wrote to Schweinitz, "I have the pleasure of sending you six copies of your work making part of [our] 4th vol. N. S." (Mycologia 9: 198. 1917). The "Syn. Fung. Am. Bor." was then issued some time between May 24th and July 29th, 1832. Now the *Transactions* were "published in numbers, at short intervals" (Amer. Phil. Soc. Tr. n. s. 4: [iii]. 1834), and the "Synopsis," published as "Article VIII" (Amer. Phil. Soc. Tr. n. s. 4: xii. 1834), apparently constituted such a number. The status of Schweinitz's paper when first issued was therefore not that of a "separate" (ascribed to it by Shear & Stevens in Mycologia 9: 198. 1917) but that of a number of a serial appearing at irregular intervals; and its date of publication is not 1831, nor 1834, that of the volume of which it forms a part, but about the middle of the year 1832.

I am indebted to Miss Marjorie W. Stone of the Gray Herbarium and to the Widener Library of Harvard University for assistance in finding early notices of the *Schriften*, and to the Farlow Library of Harvard and the Biological Science Library of Brown University for access to their copies of Schweinitz's work.



## A NEW PSEUDONECTRIA ON PACHYSANDRA

B. O. DODGE

(WITH 13 FIGURES)

A brief account of canker disease of pachysandra was recently published by the writer (1944). It had been observed that the species of *Volutella* present on cankered or blighted stems, and proved by tests to be the cause of the disease, was not the species described by Hutchinson (1929). Dr. Freeman Weiss in a letter had pointed out that Clinton (1934), White (1935), and Pirone (1942), had reported on the same disease independently. There is, then, complete agreement that the conidia of the "long spored" *Volutella* are about 14–20  $\mu$  in length, while those of *V. Pachysandrae* Hutchinson were only 2.3–6  $\mu$  in length. Hutchinson (1929) says in his description of the sporodochium: "minutis 5–6 mm. in diameter." These measurements, though repeated three times, might have been a misprint. The stems themselves are often not over 6 mm. in diameter. A 6 mm. sporodochium could not very well be called "minute."

Pirone (1942) gives us an excellent description of the disease. He also reports on his inoculation experiments, proving for the first time that this long-spored *Volutella* is a wound parasite capable of appearing in epidemic form.

Just what fungus Hutchinson had before him the writer cannot make out from an examination of what is labeled as co-type material loaned by Dr. Weiss. There can be no question as to the real cause of the canker-blight disease of pachysandra. It is the long-spored *Volutella* which all, except Hutchinson, have found on this host. The sporodochia (see Dodge 1944, p. 162) vary in size up to about 400  $\mu$  in diameter. The conidia are hyaline, one-celled, 14–24  $\times$  2–4  $\mu$ , pointed at the ends. In culture on potato dextrose agar the conidia are in mass salmon-pink and vary more in size and shape. The tapering hairs which are faintly colored, and 100–200  $\mu$  long and 5–10  $\mu$  broad, at the base, may appear as

soon as the sporodochium breaks through the epidermis. They may also grow out later either from around the margin or up through the conidiophores. Ordinarily the sporodochia are dull amber or ochraceous, or, according to White (1935), russet colored. From about the first week in June one may expect to find sporodochia which are rather reddish in color, indicating that they are becoming stromata on which perithecia will develop. During July, especially in dry weather, it seems, fewer new sporodochia bearing masses of conidia are present. Stromata with from one to several incipient perithecia are very abundant. Even in the youngest perithecial body there appears at the center a little spot suggesting the beginning of an ostiolar structure (FIG. 5). In a few crushed mounts two or three thread-like flexuous hyphae were found growing out at this point (FIGS. 5, 6). It may be that they are the receptive structures. Whether the clusters of branched sporophores, such as are shown in figure 7, represent spermogonia or not is also a question. Apparently during the summer incipient perithecia develop on stromatic masses which are reddish in color even as they burst through the bark. This means that in nature the stroma may develop without first functioning as a sporodochium. If stems bearing such stromata are moistened well and held in a damp chamber the stromata sporulate so that masses of conidia are formed.

Young perithecia are roughly granular. This is due to short, coarse, light-yellowish to reddish setae (FIG. 10) which project a short distance from the wall of the perithecium. The dome of the mature perithecium is usually rather smooth. It may be that some of the stubby hairs slough off as the fruit body expands and matures. Figures 8 and 9 show the surface condition in section diagram. When mature perithecia, which are about  $230\text{--}280 \times 200\text{--}250 \mu$ , are picked off, some of the stroma,  $100\text{--}150 \mu$  in thickness, is often attached to the base (FIG. 9). Even mature perithecia may collapse when dry, but after the full complement of asci, some two hundred or more, develop, the perithecial wall is more apt to remain firm and retain its form. The color varies slightly from orange-red to carmine-red.

Mature asci are about  $60\text{--}80 \times 7\text{--}10 \mu$ . Figure 11 shows the distribution of the ascospores in three asci. The spores are about

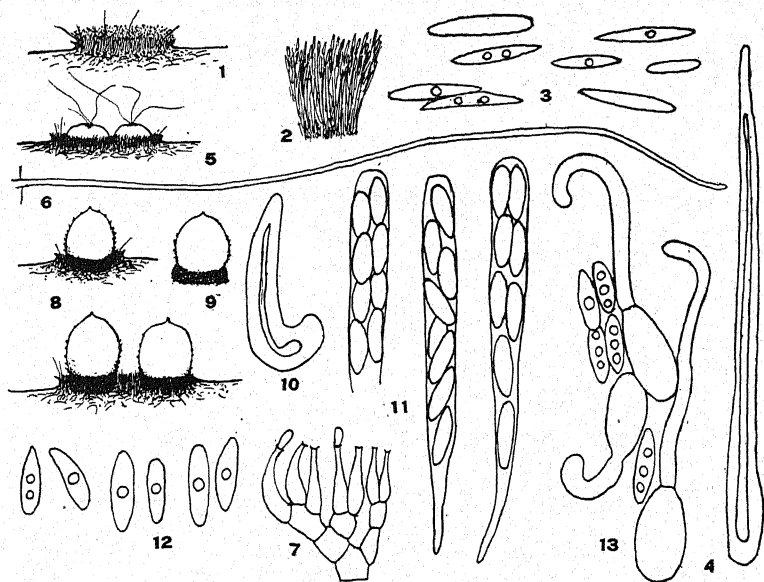
10–15  $\times$  3–4.5  $\mu$ , and are usually marked by one or more oil droplets (FIG. 12). The droplets were not drawn in in the spores shown in figure 11. The method of spore dispersal has not been observed. Occasionally one finds perithecia from which the dome part has broken away completely, leaving only a shell for a basal portion. An ostiolar opening is certainly not very evident, even in crushed mounts of mature perithecia.

Ascospores germinate very readily even while they are still inclosed in the ascus. That the spores swell greatly as they germinate is clear from figure 13, where the perfectly mature and normal spores, which have not yet grown, are shown with the same magnification to be much smaller. Here three of the eight spores had already germinated within 18 hours. The other five would, no doubt, have germinated later.

Cultures from single ascospores are like those from single conidia. As a rule, mixed cultures derived from several spores from the same ascus are brighter colored and often a little more vigorous than are cultures from single ascospores or conidia. The cultural characters, as well as the fact that perithecia so commonly develop directly from old sporodochia functioning as stromata, are further evidence of the connection between the *Volutella* and the perithecial stage. The first conidia formed on mycelia from the two kinds of spores, conidia and ascospores, may be rather large and have rounded ends (FIG 3 above), but most conidia in old cultures are more broadly spindle-shaped and have sharply pointed ends. Conidia are usually longer than are the ascospores. Living leaves and stems of *pachysandra* inoculated with conidia from ascospore cultures developed typical *Volutella* sporodochia and conidia.

Since the ascocarpic stage described above clearly belongs in the family Nectriaceae, it remained to determine to which genus of this family the species should be referred. After consultation with Dr. F. J. Seaver, who monographed the Hypocreales some years ago, it was concluded that the species belongs in the genus *Pseudonectria* Seaver (1909). He designated *Nectria Rous-seliana* Mont. as the type of the genus. Further indications that these two species are congeneric are: First, both have a *Volutella* for their conidial stage, and, second, both occur on members of the

same host family Buxaceae. Furthermore, a fact not ordinarily observed is that the perithecia of *Pseudonectria Rousseliana* (Mont.) Seaver (1909)<sup>1</sup> sometimes develop from the *Volutella* stroma. Weese (1932), writing from Höhnelt's notes, says of *Volutella Buxi* (DC.) Berk.: "Häufig bilden sich am Polster auch die Perithezien der *Pseudonectria Rousseliana* (Mont.)." The writer has also observed that while most of the perithecia he has found on boxwood leaves arise directly from a superficial mycelium, occasionally they may arise from a definite stromatic



FIGS. 1-13. *Pseudonectria pachysandricola*.

tissue resembling an old sporodochium, well decorated with characteristic hairs. This character, the origin of perithecia from stromata, as noted above, is very prominent in the species on *pachysandra*. It is, therefore, proposed to describe it as a new species of *Pseudonectria*. Those who follow Seaver's (1909) scheme of placing genera with stromata and those without stro-

<sup>1</sup> Seaver (1909) really made this combination by inference, and we are giving him credit for the combination although some might differ with us on this point.

mata in different tribes, will simply shift the genus *Pseudonectria* from the tribe Nectrieae to the tribe Creonectrieae.

***Pseudonectria pachysandricola* sp. nov.**

Peritheciis sanguineis subovoideis vel subglobosis,  $240\text{--}280 \times 200\text{--}225 \mu$ , confertis stromate erumpentibus, ostiolo minuto papillato; ascis subclavatis,  $60\text{--}80 \times 8\text{--}10 \mu$ , octosporis; ascosporis uniseriatis vel biseriatis, non septatis, hyalinis anguste ellipsoideis,  $10\text{--}15 \times 3\text{--}5 \mu$ .

Status conidicus ***Volutella pachysandricola***. Sporodochiis ambraceis,  $100\text{--}400 \mu$  diametro; setis  $100\text{--}200 \times 5\text{--}8 \mu$ ; conidiis hyalinis fusiformibus,  $14\text{--}20 \times 2\text{--}4 \mu$ , guttulatis.

Perithecia  $240\text{--}280 \times 200\text{--}225 \mu$ , subovoid to subglobose, usually arising singly or several in a group from an old sporodochium of the *Volutella* stage, which becomes a stromatic base, orange-red to carmine-red, at first rough, due to short, thick-walled setae, with a short papillate ostiole; asci clavate,  $60\text{--}80 \times 8\text{--}10 \mu$ , 8-spored; ascospores hyaline, at first 1-seriate, becoming irregularly 2-seriate, narrowly ellipsoid, 1-celled, guttulate,  $10\text{--}15 \times 3\text{--}5 \mu$ .

Conidial stage. Sporodochia ochraceous to amber or light russet,  $100\text{--}400 \mu$  in diameter, with colorless or only faintly colored 1-celled setae,  $150\text{--}200 \mu$  long,  $5\text{--}8 \mu$  thick at the base; conidiophores long, narrow, branched, pale-tan in mass or somewhat orange-reddish as the sporodochium becomes a stroma; conidia hyaline, 1-celled, spindle-shaped,  $14\text{--}20 \times 2\text{--}4 \mu$ , guttulate.

On *Pachysandra terminalis*, spring and summer.

Type locality: New York.

Distribution: Eastern United States.

Illustrations: Jour. N. Y. Bot. Gard. 45: 162. 1944.

SUMMARY

The canker-blight disease of pachysandra is caused by a new species of ascomycete, *Pseudonectria pachysandricola*, which is a wound parasite. The perithecia usually arise from stomata which represent the basal remains of sporodochia of the *Volutella* stage. The perithecial stage follows closely the conidial stage which is most in evidence during May and June, at least during periods where moisture is plentiful.

The connection between the two stages has been established culturally and by inoculation tests.

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## EXPLANATION OF FIGURES

Figs. 1, 2, 5, 8 and 9 sketched without regard to exact proportions. Other figures drawn with the aid of camera lucida and oil immersion lens.

Figs. 1-13. *Pseudonectria pachysandricola*. 1, section of a sporodochium of the *Volutella* stage; 2, cluster of conidiophores with conidia from a crushed mount; 3, conidia of various sizes and shapes; 4, a rather short, thick hair from a sporodochium; 5, two incipient perithecia arising from a sporodochial stroma, the flexuous hyphae may represent receptive organs; 6, one of these hyphae highly magnified; 7, branched cells resembling spermatogonia, two of which are just forming microconidia? (from a crushed mount of a stroma with incipient perithecia); 8, 9, sketches to show shape and rough surface of walls of perithecia, the granules representing stubby hairs such as shown in figure 10; 11, three asci with spores variously distributed, oil droplets not indicated; 12, individual ascospores; 13, three of the eight spores from an ascus had germinated after swelling considerably, the other five spores with oil droplets are drawn to the same scale; the ascus wall had disappeared.

## A NEW SPECIES OF *ALTERNARIA* ON FRUIT OF PHOENIX DACTYLIFERA<sup>1</sup>

DONALD E. BLISS

(WITH 3 FIGURES)

An interesting new species of *Alternaria* has been found among the fungi associated with the spoilage of date fruits in the Coachella Valley, California. This fungus is described as follows:

### *Alternaria stemphylioides* sp. nov.

Coloniae in agar Czapekii effusae, atro-olivaceae usque atrea; hyphis hyalinis, 3–6  $\mu$  in diam., septatis, ramosis; conidiophoris simplicibus vel ramosis, septatis, tenuibus, ad apices non inflatis; 3–8  $\mu$  in diam., usque 200  $\mu$  longis, tenuiter tunicatis, cellulis apicalibus atro-brunnescentibus, geniculatis, cicatricosis et latioribus quam cellulis hyalinis basilaribus; conidiis acrogenis, solitariis vel 2–3-catenulatis, brunneo-olivaceis, vetustis obscuriscentibus, crasse tunicatis, verrucosis, forma variis, ovalibus, ovatis, rotundis, subangularibus vel obclavatis, ad septa constrictulis, muriformibus, septis transversalibus 0–9 (plerumque 1–4), longitudinalibus 0–3, magnitudine variis, rostro incluso 14–77  $\mu$  (plerumque 16–28  $\mu$ ) longis, 10–17  $\mu$  latis, mediis  $26.1 \times 12.7 \mu$ , rostratis vel erostratis; conidiis secundariis acrogenis e rostris conidiorum primariorum conidiophora secundaria formantibus productis.

Hab. in fructibus *Phoenixis dactyliferae* L., Indio, California.

Colonies on Czapek's agar, effused, dark olive to black; hyphae hyaline, 3–6  $\mu$  in diameter, septate, branched (FIG. 1, D). Conidiophores simple or branched, septate, slender, not swollen at apex, 3–8  $\mu$  in diameter, up to 200  $\mu$  long, thin-walled, apical cells becoming dark brown, geniculate, scarred, and broader than the hyaline basal cells (FIG. 1, A, C, G, H). Conidia acrogenous, solitary or 2–3-catenulate, brownish olive, darkening with age, opaque, thick-walled, verrucose, irregularly shaped, oval, ovate, rotund, subangular, or obclavate, slightly constricted at the septa, muriform, with 0–9 (mostly 1–4) transverse and 0–3 longitudinal septa; size variable: length (including beak) 14–77  $\mu$  (mostly 16–28  $\mu$ ), breadth 10–17  $\mu$ , and mean,  $26.1 \times 12.7 \mu$ ; nonbeaked or beaked, (FIG. 1, B, G, H, I). Secondary conidia produced acrogenously on the beaks of primary conidia, these beaks becoming secondary conidiophores (FIG. 1, B, r; G, H, I).

HABITAT: Fruit of *Phoenix dactylifera* L., Indio, California.

<sup>1</sup> Paper No. 510, University of California Citrus Experiment Station, Riverside, California.

Types: Type specimen on Czapek's agar, deposited with the Mycological Collections of the Bureau of Plant Industry, Beltsville, Maryland. Cotypes sent to the Imperial Mycological Institute, Kew, Surrey, England; to the New York Botanical Garden, Bronx Park, New York City; and to the herbaria of the University of California, Berkeley, California, and of the University of California Citrus Experiment Station, Riverside, California.

Although chains of 2 and sometimes 3 conidia may occur, most of the conidia in *Alternaria stemphylioides* are solitary. There is a strong tendency toward unlimited apical elongation of the conidiophore. Spores are borne acrogenously, but may be moved rather quickly into lateral positions on the conidiophore by the elongation of the apical cell slightly to one side of the point of attachment. The elongating apex, either with or without cell division, forms a second conidium acrogenously, and then may repeat the process more or less indefinitely until as many as 15 conidia have been formed. These conidia may remain attached to the conidiophore or may be detached, leaving scars at the points of attachment.

Old conidiophores (FIG. 1, C) are geniculate, owing to the bending and distortion of the growing apex during the process of spore formation. The apical cells are usually broader than those at the base and they may be slightly swollen. There appears to be no thickening of the side walls, however, and no hyphal growth through the apical spore scar to form a new conidium, as illustrated and described by Wiltshire (8) for the true *Stemphylium*.

When grown on Czapek's agar (see "Cultural Characters"), some of the primary conidia become beaked (FIG. 2) and produce secondary conidia from the apex (FIG. 1, G), as is common in *Alternaria*. But at this point the tendency toward catenulation of spores usually stops. The beaked spores then continue to elongate at the apex, and secondary spores, although borne acrogenously, are pushed into lateral positions. Thus the beaks of these beaked primary conidia become secondary conidiophores with transverse septa, geniculations, and spore scars (FIG. 1, B, r; I). Chains of 3 spores are comparatively rare. In one instance 7 per cent of the spore chains contained 3 spores; the others contained only 2 spores each.



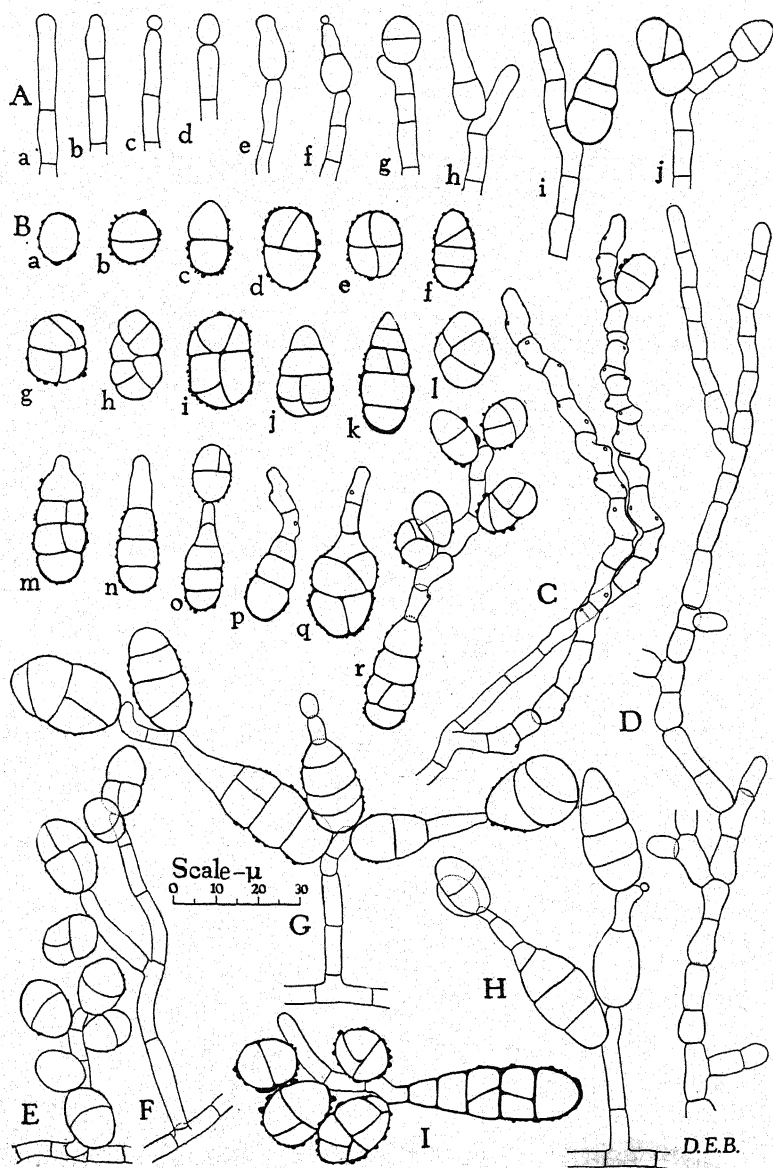


FIG. 1. *Alternaria stemphylioides*. A, a-j, young, rapidly growing conidiophores showing different stages in the development of conidia; B, conidia: a-l, nonbeaked; m-r, beaked—r, a primary conidium with elongated beak bearing five secondary conidia; C, an old, branched conidiophore with numerous cross walls, geniculations, and spore scars; D, mycelium; E and F,

Conidia of *Alternaria stemphylioides* are first seen as small, hyaline, spherical cells (FIG. 1, *A*, *c*, *f*; *H*). Swelling and elongation of the young spore is accompanied by the formation of the major transverse septum; later, other transverse, oblique, or longitudinal septa are formed (FIG. 1, *A*, *B*). The older spores on the conidiophore are usually larger than the younger ones. This is especially true where the oldest spores are beaked. Young spores are mostly regular in shape and have a smooth surface. Older spores sometimes become irregular in shape because of secondary cell division and growth, and are usually warty. The larger warts are blunt, irregular in shape, and about  $1\ \mu$  in diameter. The spores, except for their subhyaline beaks, become very dark with age, and the septa can only be seen with difficulty. Constrictions at the septa are most pronounced in spores of irregular shape.

#### CULTURAL CHARACTERS

*Alternaria stemphylioides* is one of the fungi less commonly associated with spoilage of Deglet Noor dates in California. I have isolated it only twice: the first isolate (B-402) was obtained October 11, 1935, from a mature date having a soft, watery side-spot lesion with darkened center; the second isolate (B-718) was taken January 29, 1943, from another ripe fruit with a reddish-brown side spot. In both instances the symptoms of disease were similar to those usually associated with the side spot caused by *A. Citri* Ellis and Pierce em. Bliss and Fawcett (1).

Isolate B-402 had been cultured on corn-meal agar for a period of seven years before it was studied intensively. Because of the dark, oval-shaped, nonbeaked spores which it developed on this medium (FIG. 1, *E*, *F*), it had been tentatively referred to the genus *Stemphylium*. When cultured on Czapek's agar, however, this isolate produced chains of 2 or 3 spores, and numerous spores with beaks. The spores varied greatly in size and shape. The change was so marked that I suspected contamination by some form of *Alternaria*. But after culturing single spores of different

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conidiophores and conidia as commonly produced on cornmeal agar (all other drawings are from the fungus as grown on Czapek's agar); *G* and *H*, young conidiophores with beaked primary and nonbeaked secondary conidia; *I*, primary conidium with elongating beak from which four secondary conidia have formed. ( $\times 570$ .)

kinds from the colony, I discovered that all the spores belonged to the same fungus, and that these changes in spore form could be reproduced at will by varying the cultural environment.

Two strains (*A* and *B*) of isolate B-402 were retained for further studies. Strain *A* had originated from a beaked spore; strain *B*, from a spore without a beak. The development of these strains was observed in petri-dish cultures using five kinds of agar media (table 1). After 8 days at 26° C., the colonies on glucose

TABLE 1  
DEVELOPMENT OF STRAINS OF *ALTERNARIA STEMPHYLOIDES* ON  
DIFFERENT CULTURE MEDIA \*

Medium	Mean radius of colony (mm.)	Spore size †				Beak formation	
		Length (μ)		Width (μ)		Number of spores observed	Percentage of beaked spores
		Range	Mean	Range	Mean		
Strain A							
Corn-meal agar.....	13	14-27	18.9	10-18	13.1	166	2.4
Glucose potato agar.....	22	13-33	19.6	9-17	13.2	170	7.1
Czapek's agar ‡.....	21	11-26	18.0	8-15	12.0	184	8.2
Vegetable agar §.....	22	12-39	21.3	8-15	11.4	223	12.6
Water agar.....	31	12-31	18.5	8-17	13.4	197	5.1
Strain B							
Corn-meal agar.....	13	14-23	18.1	10-16	13.2	388	0.0
Glucose potato agar.....	17	13-29	18.9	8-17	12.2	307	10.1
Czapek's agar ‡.....	15	12-34	20.4	8-15	11.4	282	13.5
Vegetable agar §.....	19	12-45	21.4	9-19	12.3	565	9.7
Water agar.....	32	12-31	20.0	9-22	14.4	400	4.2

\* Cultures incubated 8 days at 26° C.

† Based on measurements of 25 spores from each colony.

‡ Containing 3 per cent sucrose.

§ See Mrak *et al.* (3).

potato agar, Czapek's agar, and vegetable agar (3) were dense and greenish black, while the colonies on the corn-meal and water agars were sparse and lighter colored. The mycelial growth rate was most rapid on water agar and more than twice that on corn-meal agar. The percentages of beaked conidia formed on the various media showed marked differences and were as follows: on corn-meal agar, 0.0 to 2.4; on glucose potato agar, 7.1 to 10.1;

on Czapek's agar, 8.2 to 13.5; on vegetable agar, 9.7 to 12.6; and on water agar, 4.2 to 5.1. Strains *A* and *B* gave reasonably similar responses in this experiment.

Further studies were then made on strain *B* with 2 per cent Czapek's agar (Czapek's culture solution [5] plus 2 per cent agar) containing different percentages of sucrose. To four lots of a standard nutrient solution,<sup>2</sup> sucrose was added in amounts of 0.0, 15.0, 30.0, and 60.0 grams, respectively, on the basis of each 1000 ml. of the medium. Petri-dish cultures of the fungus, after an incubation period of 13 days at 26° C., on the different media, showed very large differences in the percentages of beaked spores (table 2). On the first lot of media (without sucrose) the per-

TABLE 2

SPORE SIZE AND BEAK FORMATION IN ALTERNARIA STEMPHYLOIDES, IN RELATION TO THE PERCENTAGE OF SUCROSE IN THE CULTURE MEDIUM \*

Culture medium †		Spore size ‡				Beak formation—spores at			
Lot	Percent- age of sucrose added	Length (μ) §		Width (μ)		Center of colony		Margin of colony	
		Range	Mean	Range	Mean	Number observed	Per cent beaked	Number observed	Per cent beaked
1	0.0	13-27	17.0	8-16	12.1	2,949	2.2	327	1.5
2	1.5	15-75	22.0	9-18	12.9	4,003	12.5	1,025	19.5
3 ¶	3.0	14-77	26.1	10-17	12.7	4,033	18.5	1,084	28.8
4	6.0	14-57	21.2	9-19	12.9	3,933	13.8	1,625	11.9

\* Cultures incubated 13 days at 26° C.

† Unless otherwise specified, the culture medium used in these studies was the standard nutrient solution described in text footnote 2.

‡ Based on measurements of 100 spores from the margin of each colony.

§ Including beaks.

¶ Czapek's agar (Czapek's culture solution [5] plus 2 per cent agar).

centages of beaked spores were 2.2 near the central or oldest part of the colony, and 1.5 at the margin or youngest part of the colony, whereas on the third lot of media (3 per cent sucrose) the percentages were 18.5 and 28.8, respectively. The proportions of beaked spores from lots 2 and 4 were of intermediate value. Data for mean length of spores from the different media (table 2) paralleled those for beaked spores, partly because the beaks had

<sup>2</sup> The standard nutrient solution contained  $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ , 0.5 gram;  $\text{KH}_2\text{PO}_4$ , 1.0 gram;  $\text{KCl}$ , 0.5 gram;  $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ , 0.01 gram;  $\text{NaNO}_3$ , 2.0 grams; and distilled water, 1000 ml.

been included in the measurements. The number of transverse septa (table 3) was greater in spores cultured on media rich in sucrose than in spores from media containing little or no sucrose. The different media had only slight effect, however, on the width and on the longitudinal septation of the conidia. After 5 days at 26° C., average length of mycelial growth was 21, 12, 12, and 15 mm., respectively, for the four lots of media. Lot 1 (without

TABLE 3

SPORE SEPTATION \* IN *ALTERNARIA STEMPHYLIOIDES*, IN RELATION TO THE PERCENTAGE OF SUCROSE IN THE STANDARD NUTRIENT SOLUTION †

Number of septa	Percentage of spores having							
	Transverse septa				Longitudinal septa			
	Lot 1 (sucrose 0.0 per cent)	Lot 2 (sucrose 1.5 per cent)	Lot 3 (sucrose 3.0 per cent)	Lot 4 (sucrose 6.0 per cent)	Lot 1 (sucrose 0.0 per cent)	Lot 2 (sucrose 1.5 per cent)	Lot 3 (sucrose 3.0 per cent)	Lot 4 (sucrose 6.0 per cent)
0	0.6	0.0	0.0	0.0	25.0	28.8	40.0	24.4
1	73.1	36.9	53.7	40.0	33.8	30.6	36.3	38.8
2	21.2	17.5	21.9	26.3	40.0	35.6	21.9	35.6
3	5.0	36.9	15.0	30.6	1.3	4.4	1.9	1.3
4		4.4	3.8	0.0		0.6		
5		3.8	1.9	1.9				
6		0.6	0.6	0.0				
7			0.6	0.0				
8			1.9	0.6				
9			0.6	0.0				
19				0.6				

\* Each observation based on 160 spores from margin of colony. Cultures incubated 27 days at 26° C.

† From 0.0 to 6.0 per cent sucrose and 2.0 per cent agar were added to the standard nutrient solution described in text footnote 2.

sucrose) produced a sparse but rapid-growing colony which resembled a colony on water agar, previously mentioned (table 1). Slower-growing but very dense colonies were produced on the three lots that contained sucrose.

*Alternaria stemphylioides* was also cultured on sterile date fruit and on citrus fruit slices.<sup>3</sup> Only a few conidia developed on the dates, but there were many intercalary swellings in the mycelium. Development of the fungus on citrus fruit was reasonably similar to that on agar, and from 4 to 11 per cent of the conidia were beaked. No ascogenous stage was discovered.

<sup>3</sup> From fruits of Eureka lemon, Valencia and Washington Navel orange.

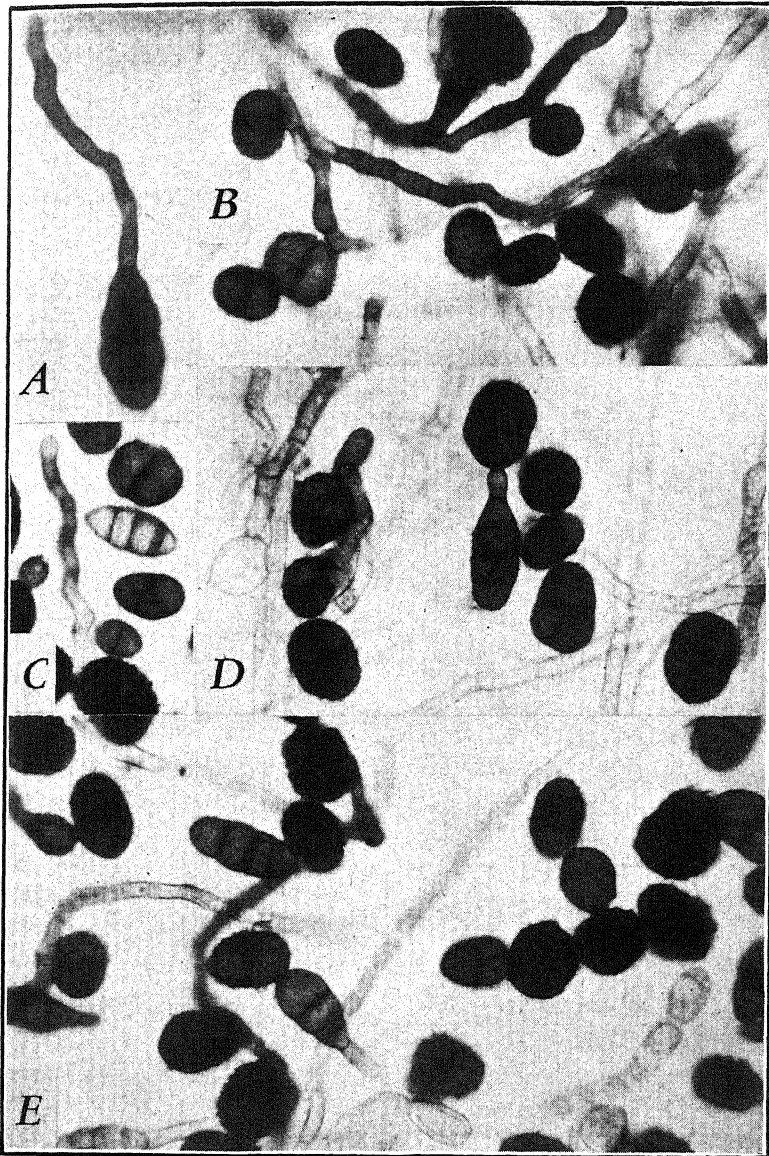


FIG. 2. *Alternaria stemphylioides* ( $\times 593$ ) on Czapek's agar, after 17 days at  $26^{\circ}$  C. A, conidium with long beak showing geniculations, septa, and spore scars; B, conidia, dark conidiophores, and hyaline mycelium; C, conidiophore and conidia; D and E, mycelium and conidia, some of which are beaked.

Culture B-402, strain *B*, has been selected as the type culture for *Alternaria stemphylioides*. Based on the measurement of 100 conidia from a culture incubated 13 days at 26° C., the distribution curves (FIG. 4) for length and width are fairly steep. The length curve, however, is "skew" in the upper range of values because of the beaked spores in the population. Analogous curves for culture B-718 (not shown) are similar to those for culture B-402. The two isolates are thought to be identical.

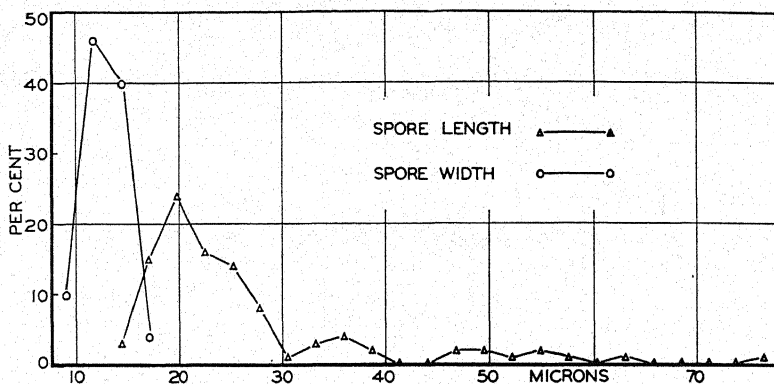


FIG. 3. Percentage distribution of spore sizes of *Alternaria stemphylioides*. The curves represent measurements of 100 spores from a colony on Czapek's agar, incubated 13 days at 26° C.

#### TAXONOMY

Because of its beaked spores and unswollen conidiophores, the fungus described in the present paper is now considered to be a species of *Alternaria* Nees. When first observed, however, it was tentatively referred to the genus *Stemphylium* Wallroth, and to that particular group of species termed *Pseudostemphylium* by Wiltshire (8).

Similarities have been noticed between *Alternaria stemphylioides* and several other fungi. *Stemphylium botryosum* sensu Oudemans, as illustrated and described by Wiltshire (8), is similar except that "sometimes the conidiophore, instead of growing out immediately below the conidium does so lower down so that it is branched." Wiltshire (8) considers *S. botryosum* of Oudemans to be identical with *S. lanuginosum* Harz. Species allied to *S. lanuginosum* comprise the group *Pseudostemphylium*.

The published photographs of *Stemphylium dendriticum* De Sousa da Camara (2) are similar to *Alternaria stemphylioides* as it appears on corn-meal agar, but since the spores of *S. dendriticum* are described as acro-pleurogenous and without beaks, the two fungi are apparently distinct. *S. congestum* Newton (4) also shows similarity but, in the absence of beaked conidia, it may properly belong with the group *Pseudostemphylium*.

Perhaps the closest similarity thus far noted is that between *Alternaria stemphylioides* and a *Stemphylium* saltant of an *Alternaria* described by Wiltshire (6). He found that, when cultured on Richards' agar, an *Alternaria* isolated from grapes repeatedly produced saltating sectors of a *Stemphylium*-like fungus. This saltant is described in part as olivaceous black to deep olive in culture, with oval, muriform, sometimes pointed, coarsely warted spores having 0 to 5 (mostly 3) cross septa. According to Wiltshire (6), "conidia of the *Alternaria* type occasionally occur," and the conidia, which measure  $11-38 \times 9-21 \mu$ , are sometimes "so opaque that the cross walls cannot be discerned. . . . Chains of two or three conidia are not uncommon, but the maximum number observed in a chain did not exceed four. . . . Sometimes the distal end of the spore is prolonged to form itself a short conidiophore, which again bears a small head of spores." Hyphae immersed in the agar produce nearly spherical conidia with characteristic gas bubbles at the center.

This description, except perhaps for the conidia on immersed hyphae, fits very well the description of *Alternaria stemphylioides*. It appears, however, that the modern concept of the genus *Stemphylium* changed somewhat between 1929, when Wiltshire (6) described this saltant, and 1938, when he (8) outlined the original and modern conceptions of this genus. In the later publication, Wiltshire (8) states that the characters distinguishing the genus *Stemphylium* Wallroth "are (1) that the conidiophores are swollen at the apex which bears a single terminal spore (though this may be forced into a lateral position by the continued growth of the conidiophore); (2) that the growth of the conidiophore is continued through the terminal scar, the successive swellings recognizable in an old conidiophore marking the places where conidia have been borne; and (3) that the spore shape is oval or sub-



angular, frequently constricted at the major, median transverse wall and *never beaked*." <sup>4</sup> Even after retaining within the genus the species allied to *S. lanuginosum* Harz (*Pseudostemphylium* group), it would not seem logical to include a fungus like *Alternaria stemphylioides*, in which, under certain conditions, approximately one fourth of the conidia are beaked.

On the other hand, *Alternaria stemphylioides* appears to fit quite properly in the genus *Alternaria* Nees, as characterized by Wiltshire (7). The conidia of this species are not "typically obclavate" because of the relatively low percentage of beaked spores; but oval, nonbeaked spores are common in *Alternaria*, sometimes occurring in relatively large numbers (1).

As to taxonomy within the genus, *Alternaria stemphylioides* seems to be more or less in a class by itself. The relative absence of short beaks separates it from *A. Citri* and related forms (1), although the spore dimensions are similar. The habit of forming botryose clusters of spores, the absence of long spore chains, and the predominance of oval, nonbeaked spores, tend to place this species in an intermediate position between the *A. Citri* group of *Alternaria* and the *Pseudostemphylium* group of *Stemphylium*; hence the name, *A. stemphylioides*.

#### SUMMARY

A new species of *Alternaria*, described as *A. stemphylioides*, has been isolated from fruit of the date palm, *Phoenix dactylifera* L., in the Coachella Valley, California. The conidia of this fungus are borne acrogenously but, because of the tendency toward unlimited apical elongation of the conidiophore, they are mostly pushed into lateral positions. Some of the primary conidia are beaked and develop secondary conidia. Although chains of 3 spores are found occasionally, the beak of the primary conidium usually elongates at the apex slightly to one side of the point of attachment, pushes the secondary conidium into a lateral position, and forms another spore at the apex. By repeating this process several times, the beak of the primary conidium becomes a secondary conidiophore.

<sup>4</sup> Italicized by the present writer.

The percentages of beaked spores varied considerably when the fungus was cultured on different media (corn-meal agar, glucose potato agar, Czapek's agar, vegetable agar, and water agar). Variation in the proportion of sucrose in Czapek's agar caused the production of beaked spores to vary from 1.5 per cent in cultures with no sucrose to 28.8 per cent in cultures containing 3 per cent sucrose. The size and septation of the spores were also affected by these variations in sugar content.

Although *Alternaria stemphylioides* shows marked similarity to certain species of *Stemphylium*, especially those of the *Pseudostemphylium* group, it is referred to the genus *Alternaria* because of its beaked spores and unswollen conidiophores. From the taxonomic standpoint, this new species seems to occupy an intermediate position between the *A. Citri* group of *Alternaria* and the *Pseudostemphylium* group of *Stemphylium*.

#### ACKNOWLEDGMENT

Appreciation is expressed to Miss Edith K. Cash for the preparation of the Latin description.

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## NOTES AND BRIEF ARTICLES

### THE MYCETOZOA OF NORTH AMERICA

In recent years the most active student and collector of Myxomycetes in North America has been Mr. Robert Hagelstein, whose contributions to our knowledge of these forms have been appearing in MYCOLOGIA and elsewhere for many years. It is fortunate for all students of the group that he has been able to sum up the results of his studies in a handsome volume of over 300 pages, illustrated with sixteen plates, four of which are in color. The treatment is restricted to species known to occur in North America, but since, of the 318 species which the author regards as valid, 285 are known to occur in that continent, a very representative assemblage is included. The work is based very largely on the collections in the New York Botanical Garden, interpreted in the light of the author's unequalled field experience. The colored plates are excellent; the half-tones in most cases show detail or habit fairly well, but some are distinctly disappointing.

The classification adopted is, in general, that of Lister which, however unsatisfactory, is no more so than that stemming from Macbride, and the treatment throughout is reminiscent of the Lister monograph. The keys, for the most part, are more usable than any which have yet appeared, although in some of the larger genera the number of choices to be considered is unduly large, as in those of Lister, on which they appear to be modelled.

As the author admits in his introduction, much remains to be learned about the slime molds, and there is bound to be great difference of opinion as to species limitations until more is known about the extent of variation possible when plasmodia of the same species fruit under different environmental conditions. The present reviewer would recognize a number of species reduced by Hegelstein to varietal rank or to synonymy and he would take strong exception to the wide range in spore size allowed for many species. The substitution of the name *Arcyria vitellina* for the established name *A. versicolor*, said to be in accordance with

present rules, is directly contrary to the provision of Art. 56, and the use of *Cribraria aurantia* instead of *C. vulgaris*, if these names are regarded as referring to the same species, is subject to the same criticism. Most of the changes appear, however, to be defensible, and it is to be expected that experience will justify many of them. Obviously, great care has been used to make the citations correct and the bibliography, prepared with the aid of Dr. Barnhart, is distinctly superior to any published in earlier works.

The book should be of very great service to students and it is to be hoped that it will stimulate interest in and study of a fascinating group or organisms. It is published by the author, 165 Cleveland Avenue, Mineola, N. Y. and sells for \$6.00—G. W. MARTIN.

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"The Mycetozoa of North America" by Robert Hagelstein is the latest contribution to our knowledge of this group of interesting organisms. For over 200 years they have found a more or less definite place in botanical literature. The first volume devoted to North American species was published by Macbride in 1899.

The author of the present volume has had for his studies access to the large collections of the New York Botanical Garden which include much type and authentic material. For twenty years he has made extensive field studies and is as familiar with the habitat and distribution of these forms in nature as he is with herbarium specimens. Several times it has been the privilege of your reviewer to share the enthusiasm of the author as he was making observations and collections both in the States and in the West Indies. In the introduction the development of the plasmodia and the production of the fruiting bodies is discussed and some excellent suggestions for their care and preservation are given. The point that there are opportunities for research in the morphology, physiology, and taxonomy of the group is well taken.

In the arrangement of the species within a genus especial attention has been given to a sequence based on affinities. The attempt to make a natural sequence is most laudable even though often difficult. The citations and bibliography have been carefully

prepared. Complete lists of synonyms are not given. Since they would not have added much to the length of the presentation, but would have added desirable information in some cases, their omission seems unwarranted. The book describes 285 species from North America. It is stated that the entire number of species regarded as valid in the world is 318. No theories are offered to explain how practically 90 per cent all known species occur in North America. While many species are almost world-wide in their distribution, others are limited to comparatively small areas. It seems likely that those in many other parts of the world are less well known than those in North America.

The neatly bound volume has 306 pages including glossary, bibliography, index, and explanation of plates. There are 16 full-page plates each with several figures. The illustrations are chiefly photographs of aethalia or sporangia. The book is published by the author and comes from the Lancaster Press.—FRANK D. KERN.

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#### ON SOME BASIDIOMYCETES NEW FOR THE UNITED STATES

*AGARICUS BAMBUSIGENUS* Berk. & Curt. This species has been collected at several localities in Florida. It was hitherto known only from Cuba. Murrill redescribed it under the name *Agaricus Rhoadsii* Murr. The types of both these species have been compared.

**Copelandia Westii** (Murr.) Sing. comb. nov. (*Panaeolus Westii* Murr. 1942; *Copelandia papilionacea* Bres. non Fries). As the examination of the types shows, *Panaeolus Westii*, recently described from Alachua Co., Fla., has the same characteristic colored cystidia as the species incorrectly identified with *Panaeolus papilionaceus* by Bresadola, and hitherto known from the Philippine Islands only. The genus *Copelandia* is new for the United States and for this Hemisphere in general.

**GALERINA NANA** (Petri) Kuhner. This species has previously been known only from Europe. It was described as *Naucoria nana* from Italy, later misdetermined as an *Inocybe* by Velenovsky in Czechoslovakia, and eventually recollected and correctly transferred to *Galerina* by Kuhner in France. It also occurs in Lenin-grad (coll. & det. Singer). I found it in May 1944 in my cellar

in Arlington Mass., growing on fence poles that had been stored there for the winter. *G. nana* differs from all species of *Galerina* by its cystidia which recall these of *Inocybe*.

*LACHNOCLADIUM BRASILIENSE* Lév. This species is widely different from all other so-called *Lachnocladiums* in having the hyphae of the twigs transformed into branching, colored, stiff, bristle-like bodies. Most of the species of *Lachnocladium* in the present conception are tall *Pterulas*. The name *Lachnocladium* should be reserved for fungi of the type of *L. brasiliense*, and the latter be made the type of the genus, *L. brasiliense* is frequent in Southern Florida where it forms enormous cespitose fruiting masses. It has not been recorded in continental North America before.

*LEUCOPAXILLUS GRACILLIMUS* Sing. & Smith. A larger form (pileus 50–80 mm., stipe 40–50 × 5–7 mm.) of this Brazilian species has been found by Rapp at Hunters Station, Alachua Co., Fla., and was given a herbarium name by W. A. Murrill, according to whom the fresh pileus is “lateritious, or with a small bay disk,” the lamellae pure white, the stipe milk white, the taste becoming somewhat astringent, scarcely bitter, the odor slightly farinaceous.” I found the dried pileus Pl. 6–9 E to 10 C (Maerz & Paul), or “vinaceous fawn,” or “Sorghum brown” with some “vinaceous brown,” the disk sometimes “dark vinaceous brown,” the lamellae exceedingly close (3 or more to a mm.), the spores as in the type.

*PTERULA CAPILLARIS* (Lév.) Sacc. Collected in the Florida Coastal Hammock area, and compared with the type from Java, and specimens from Ecuador and the Philippine Islands, this evidently pantropical species is a new member of the North American Flora.

*PTERULA PALLESCENS* Bres. Originally described from Africa, this species is represented (under the apparently wrong name *Calocera divaricata* Berk.) in Patouillard's Herbarium (from San Domingo) and has recently been collected by the writer near Gainesville in a mesophytic hammock. When fresh, it is rather soft, white, and has a peculiar odor of iodoform. The warty-dentate spores are unusual in the genus *Pterula*. This species will sooner or later be separated from *Pterula*.

*SCHIZOPHYLLUM UMBRINUM* Berk. This species, kindly determined by D. H. Linder, and formerly reported from Cuba and Nicaragua, has been collected by the writer in South Florida on a trunk of *Persea americana*.

*THELEPHORA MAGNISPORA* Burt. Described from Jamaica, this rare tropical species has been collected by the writer in South Florida (Royal Palm State Park), the first collection in continental North America. The spores with their  $2\mu$  long spines are unmistakable.

*TROGIA CANTHARELLOIDES* (Mont.) Pat., and its synonyms *Lentinus scyphoides* Pat. and *L. subscyphoides* Murr. have never been indicated from continental North America, nor has any species of *Trogia* ever been found in the United States. What sometimes incorrectly is called *Trogia*, is a meruliaceous species, the common Northern *Plicatura crispa* while the real *Trogias* are confined to the tropics. When collecting in Southern Florida, I found *Trogia cantharelloides* to be one of the commonest wood-inhabiting fungi, sometimes partly beautifully violet.—R. SINGER.

# MYCOLOGIA

OFFICIAL ORGAN OF THE MYCOLOGICAL SOCIETY OF AMERICA

VOL. XXXVI NOVEMBER-DECEMBER, 1944 No. 6

## NEW ASPERGILLI FROM SOIL

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(WITH 6 FIGURES)

During the past three years soils from many areas in this country and abroad have been examined at the Northern Regional Research Laboratory for the purpose of securing from natural sources molds important to the research of the Fermentation Division. In the course of this work five species of *Aspergillus* believed to be new have been isolated. All of these were obtained from southern or tropical soils, and hence can be considered as components of the microfloras of habitats characterized by a comparatively high temperature during all or part of the year.

Two types of cultures were made in the examination of these soils:

1. DILUTION CULTURES: Samples of soils were diluted with approximately 10 volumes of sterile water and shaken vigorously for a period of 10 to 15 minutes. Serial dilution in steps of 1 : 10 were then made from the resulting suspensions and plated. Dilutions employed ranged from 1-1,000 to 1-1,000,000, depending upon the source and type of the sample. For each sample three dilutions were generally plated, and as a rule, two media were employed; namely Czapek-Dox agar (5) and an acid-dextrose-

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nitrate agar employed and recommended by Smith and Humfeld (4) for the isolation of fungi from soil. Dilution plates were incubated at room temperature and desired forms were isolated as they appeared and sporulated. Plates of this type are valuable since they present some quantitative measure of the total fungus flora and of its constituent members as well. When colonies are reasonably well separated in such plates, they generally develop in a characteristic manner and can be isolated directly by means of a low-power binocular or a good-quality hand lens.

2. STREAK CULTURES: Plates of hay infusion agar of the composition previously employed by Raper (1) for the isolation of slime molds were streaked with from one to three loopfuls of the initial 1 : 10 suspension. These plates were likewise incubated at room temperature and were examined with a low-power binocular at 7 to 10 days. No molds grow luxuriantly upon this medium, but a tremendous number and variety of forms can make a very limited development. Furthermore, most forms sporulate well and generally appear fairly characteristic, although commonly of smaller dimensions than upon richer substrata. On the whole, hay infusion agar constitutes a very satisfactory medium for the isolation of molds from natural sources, and one can regularly expect to find some forms in these cultures which do not occur, or cannot be recognized, upon the dilution plates described above.

All of the species currently described have been under observation for a period of at least one year and some for approximately two years. They have been grown upon a wide variety of culture media including Czapek's solution agar and various modifications of the same, and malt extract, potato dextrose, and hay infusion agars. A wide range of incubation temperatures have been employed. Since environmental conditions substantially affect their appearance, these factors will be given somewhat greater emphasis than is generally necessary in describing species of *Aspergillus*.

***Aspergillus janus* sp. nov.**

Coloniae cum mutatione substrati temperaturaeque colore et textura multo variae; capitulis conidicis generum duorum, aut ambobus aut unis aut alteris praesentibus: (1) capitulis magnis albis in conidiophoris longis, vesiculis clava-

tis praeditis, (2) parvis, atro-viridibus in conidiophoris brevibus vesiculis ovatis praeditis oriundis. Capitula alba laxa catenulis conidicis radiantibus et divergentibus 150–200  $\mu$  longis composita; conidiophoris longis, tenuibus, plerumque 2–3.5 mm. longis, 8–10.5  $\mu$  crassis, levibus, hyalinis; vesiculis clavatis membrana tenui praeditis, 45–60  $\times$  15–18  $\mu$ , totis sterigmatibus tectis; sterigmatibus in seriebus duabus, primariis 7–10  $\times$  3.5–4.5  $\mu$ , secundariis 6–8  $\times$  2.5–3  $\mu$ , conidiis levibus, hyalinis, globosis usque subglobosis, plerumque 2–2.5  $\mu$ . Capitula viridia compacta, juvenilia radiantia, matura columnaria, saepe in columnas duas divergentes fissentia, primum cyanea usque cyaneo-viridia, vetusta atro-olivaceo-grisea, 60–75  $\mu$  in diam. 200–300  $\mu$  longa; conidiophoris erectis, 300–400  $\times$  6.5–8  $\mu$ , levibus, hyalinis; vesiculis membrana tenui praeditis, plerumque ovoideis et saepe elongatis; totis fertilibus, 20–30  $\times$  12–18  $\mu$ ; sterigmatibus in seriebus duabus, primariis 7–10  $\times$  4–4.5  $\mu$ , secundariis 6–8.5  $\times$  2–2.8  $\mu$ ; conidiis in massa atro-viridibus, spinulosis, globosis, plerumque 3.2–4.0  $\mu$ ; cellulis "hülle" crasse tunicatis, globosis usque subglobosis vel elongatus, interdum curvatis et saepe lobatis. In culturis e solo, Panama.

Species characterized by conidial heads of two distinct types, (1) large white heads borne upon long conidiophores terminating in strongly clavate vesicles and (2) smaller, dark green heads borne upon short conidiophores with typically ovate vesicles.

Colonies varying greatly in color and in texture depending upon the substratum and the temperature of incubation. Upon Czapek's solution agar (FIG. 1A) at 24°C., colonies spreading irregularly, after two weeks usually consisting of a central floccose mass 1 to 2 mm. deep, pale yellow-buff in color, bearing few to abundant fruiting structures surrounded by an irregular zone of crowded fructifications with dark green heads occurring in a dense stand adjacent to the substratum and with numerous long-stalked white heads projecting above this layer, hülle cells commonly present in scattered to abundant irregular masses, light yellow in color; reverse in dull yellow to light brown shades. When incubated at 20° C. colonies more restricted, less floccose and consisting almost exclusively of a dense stand of long-stalked white heads, with small green heads absent or developing only in age and arising from trailing aerial hyphae entwined among the white fruiting structures. When incubated at 30–32° C. colonies close-textured, predominantly green but with central area commonly showing irregular patches of massed hülle cells, buff to dull yellow in color. Conidial heads abundant and consistently dark green in color. Reverse in dull brown shades.

White conidial heads loose in texture, consisting of radiating and divergent chains of conidia, commonly 150 to 200  $\mu$  in diameter, occasionally larger (FIG. 1C). Conidiophores long, thin, mostly 2 to 3.5 mm. in length by 8 to 10.5  $\mu$  in diameter, occasionally larger, erect, essentially uniform in diameter throughout but often marked by numerous and irregularly spaced constrictions.

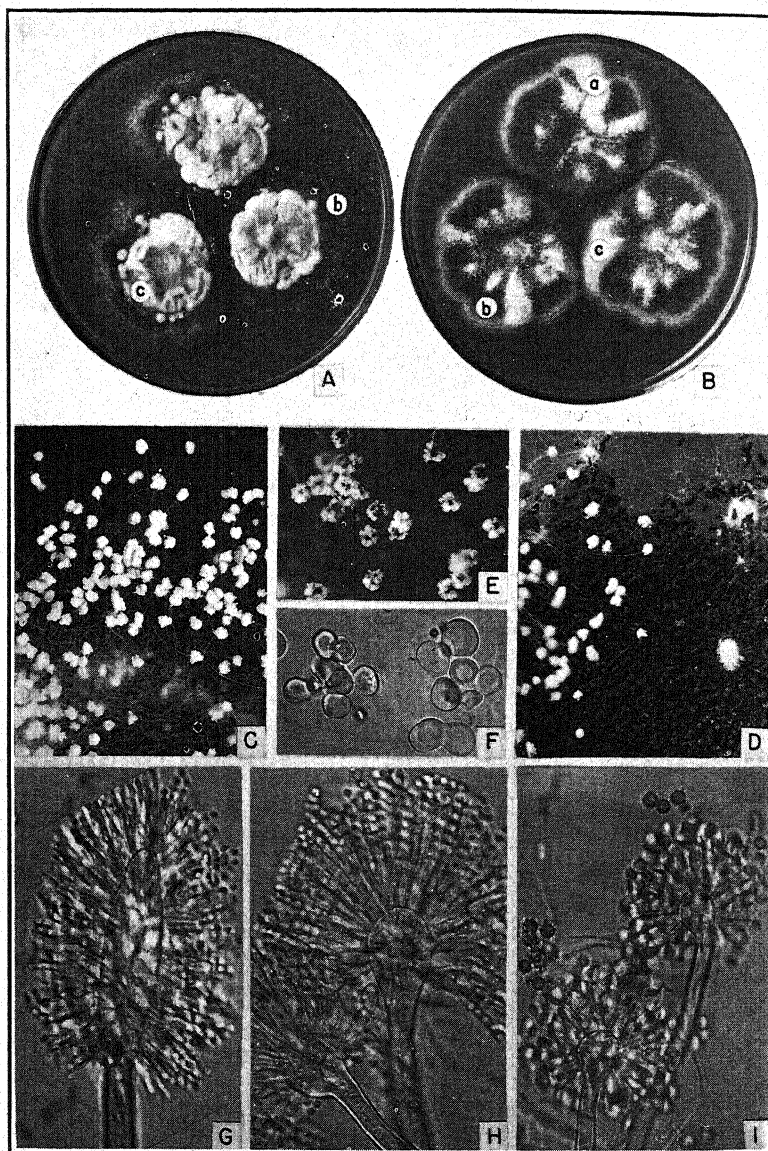


FIG. 1. *Aspergillus janus*; NRRL No. 1787. A and B, colonies on Czapek's solution agar and malt agar, respectively, showing *a*, scattered white conidial heads, *b*, crowded green heads, and *c*, massed hülle cells, two weeks old, incubation at 24° C.,  $\times \frac{1}{2}$ . C, characteristic white heads borne on long thin stalks,  $\times 7.5$ . D, massed green heads in dense stand adjacent to the substratum, with white heads projecting from the left, and with localized develop-

tions, walls smooth, colorless, approximately 1 to 1.4  $\mu$  in thickness. Vesicles thin-walled, clavate (FIG. 1G), mostly 45 to 60  $\mu$  in length by 15 to 18  $\mu$  in width with individual structures larger or smaller, entire surface loosely covered by sterigmata as a rule, but often showing barren areas which may occupy any part of the sterigmatic surface. Sterigmata in two series, primaries 7 to 10  $\mu$  by 3.5 to 4.5  $\mu$ ; secondaries 6 to 8  $\mu$  by 2.5 to 3  $\mu$  (FIG. 1G). Conidia smooth, colorless, globose to subglobose, mostly 2 to 2.5  $\mu$  with maximum about 2.8  $\mu$ .

Green conidial heads compact, radiate when young, becoming columnar in age, and often spreading into two divergent columns (FIG. 1D). Heads at first in blue to blue-green shades near dark gobelin blue (Ridgway, Pl. XXXIV), becoming dark olive gray (Ridgway, Pl. LI) in age, in size commonly ranging from 60 to 75  $\mu$  in diameter by 200 to 300  $\mu$  in length. Conidiophores erect, commonly 300 to 400  $\mu$  in length by 6.5 to 8  $\mu$  in diameter, of uniform thickness throughout, walls smooth, colorless or very faintly green, approximately 1 to 2  $\mu$  thick, enlarging rather abruptly into an elongate vesicle. Vesicle thin-walled, variable in form and dimensions, but commonly ovoid and often conspicuously elongate, typically fertile over the entire area, ranging in size from 20 to 30  $\mu$  in length by 12 to 18  $\mu$  in diameter (FIG. 1I). Sterigmata in two series, rather loosely arranged, primaries 7 to 10  $\mu$  by 4 to 4.5  $\mu$ ; secondaries 6 to 8.5  $\mu$  by 2 to 2.8  $\mu$ . Conidia dark green in mass, conspicuously spinulose, globose, mostly 3.2 to 4.0  $\mu$ , occasionally larger or smaller.

Conidial heads of mixed character containing both white and green spores often encountered, usually borne upon long conidiophores approaching and often equalling in length those of white heads, vesicles more or less clavate, sterigmata at first bearing colorless smooth-walled conidia, but subsequently bearing dark green spinulose conidia (FIG. 1E and H).

At temperatures of 24° C. and above, thick-walled hülle cells abundant, irregular in form, commonly globose to subglobose, not infrequently elongate, commonly more or less curved and often lobed (FIG. 1F).

Colonies upon malt extract agar growing luxuriantly (FIG. 1B), generally loose in texture with aerial mycelium becoming promi-

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ment of hülle cells in two limited areas at right,  $\times 7.5$ . E, heads of mixed character with older (outer) conidia white and younger (inner) conidia green,  $\times 24$ . F, hülle cells,  $\times 350$ . G, typical white head showing clavate vesicle, double sterigmata and small, smooth conidia,  $\times 450$ . H, head of mixed character, at this stage (early) producing small white, smooth conidia,  $\times 450$ . I, typical green head, showing small, nearly globose vesicle, double sterigmata and larger, echinulate, green conidia,  $\times 450$ .

nent in age, conidial heads normally more abundant than upon Czapek's agar, the proportion of white to green heads varying with the temperature of incubation.

Colonies upon hay infusion agar spreading broadly, consisting of a thin submerged mycelium from which develop erect, white and green conidial structures, the relative proportion of these types being dependent upon the temperature of incubation; since comparatively meager growth occurs upon this medium, and since there is a minimum of aerial vegetative hyphae, it constitutes a very favorable substratum upon which to observe the formation of the contrasting fruiting structures characteristic of the species.

The binomial *Aspergillus janus* is applied to this species because of the contrasting types of conidial heads produced—literally it is a "two-faced" mold.

Type culture NRRL No. 1787 was isolated in February 1942, from Panama soil collected during the summer of 1941 by John T. Bonner of Harvard University. Three additional isolations by members of the Northern Regional Research Laboratory staff have since been made from Panama soils subsequently collected by Mr. Benjamin A. Coghill. It is believed that this species represents a normal component of the microflora of Panama. Additional evidence in support of this view is furnished by the fact that in 1925 Professor Roland Thaxter sent to Thom under the label "white Panama *Aspergillus*" a representative of this species. The form was never described by Thaxter, and viable cultures of it were lost from our collection some time prior to 1930. As the correspondence of the time is remembered, Thaxter was plagued by the presence of a small green mold which repeatedly appeared in his cultures as a "contaminant." Fortunately, the original tube received from Thaxter has been preserved, and re-examination of this culture leaves no question but that he was dealing with a strain of the species here described, and that the green form which troubled him so much was not, in fact, a contaminant but a different phase of the same fungus.

The presence of a green phase with conidial heads closely approximating *Aspergillus Sydowi* (Bainier) Thom & Church (5) definitely allies *A. janus* with this species; and in the absence of any form approximating the white conidial stage, *A. janus* is placed in the *A. versicolor* group adjacent to *A. Sydowi*.

Extensive experimental studies have established conclusively that the white and green spored forms represent different aspects of a single fungus. These studies will be considered in detail in a subsequent report.

***Aspergillus janus* var. *brevis* var. nov.**

A typo differt conidiophoris brevioribus, vesiculis minoribus, et caespitulis fructiferis viridibus et albis separatim in sectoribus radiantibus dispositis. In culturis e solo, Mexico.

The variety differs from the species in a number of particulars, foremost among which are (1) the reduced length of the conidiophores bearing both white and green heads and (2) a consistent tendency for white and green conidial structures to develop in approximately pure stands and to appear as contrasting radial sectors (FIG. 2 A and B).

White conidial heads are of the same general pattern and form as in the species, but are of somewhat smaller dimensions, are borne upon conidiophores generally less than 2 mm. in length by 6 to 8  $\mu$  in diameter, and are characterized by elongate but not strongly clavate vesicles measuring 20–25  $\mu$  by 14 to 18  $\mu$ ; conidia are smooth walled, colorless, globose to subglobose, 2.2 to 2.8  $\mu$  in diameter. Green conidial heads are compact, globose to somewhat columnar, borne upon conidiophores 75 to 125  $\mu$  by 4 to 6  $\mu$  with globose to subglobose vesicles measuring 8 to 15  $\mu$  by 10 to 18  $\mu$ ; conidia are dark blue-green, strongly echinulate, and 3.5 to 4.5  $\mu$  in diameter.

The vesicles of white heads in the variety *brevis* are of approximately the same size and form as the vesicles of green heads in the species itself, whereas the conidiophores bearing each type of head are approximately one-half the length of those bearing the same type of head in the species. The most striking character distinguishing the variety, however, is the manner in which areas of white and green heads are sharply separated along radial lines.

Conidial heads of mixed character are produced and usually can be found along the frontiers between white and green sectors. The character of the conidial heads produced is strongly influenced by the temperature of incubation, but this response is not so marked or consistent as in the species itself.

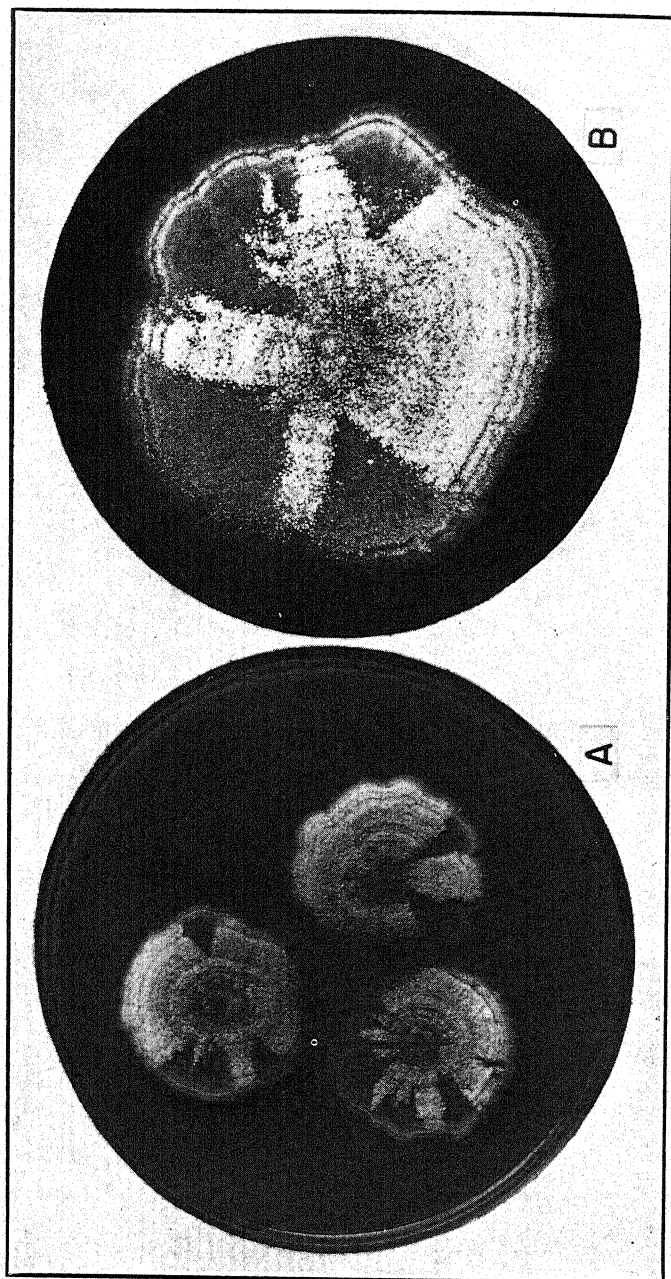


FIG. 2. *Aspergillus janus* var. *brevis*; NRRL No. 1935. A, colonies on malt extract agar, 2 weeks old, incubation at 24° C. Note marked tendency to sector along radial lines. B, single colony enlarged showing greater detail of separation of green and white sporing areas.



Type culture NRRL No. 1935 was isolated in July 1942, from a sample of soil collected in Alameda in southern Mexico, and forwarded to us in June by Mr. William B. Roos.

***Aspergillus caespitosus* sp. nov.**

Coloniae in substratis differentibus multo variantes; in agar *Czapekii* tarde crescentes, myceliis submersis, lentis, capitulis conidicis atro-viridibus hemisphaericis vel laxe columnaribus, 75–125  $\mu$  in diam., cellulis "hülle" abundantibus, cumulos conspicuos maturos rubopurpureascentes formantibus; reverso atro-purpureo; conidiophoris rectis vel subsinuosis, 250–325  $\times$  5.0–6.5  $\mu$ , crasse tunicatis, levibus, alutaceis usque pallide brunneis; vesiculis subelongatis, hemisphaerico superiore sterigmatibus tecto, inferiore sterili, saepe pallido, plerumque 15–20  $\mu$  in diam.; sterigmatibus in seriebus duabus, primariis 6.5–8.5  $\times$  3.5–5.0  $\mu$ , secundariis 6.5–8.0  $\times$  3.0–4.5  $\mu$ , typice botuliformibus; conidiis globosis, spinulosis, viridibus, plerumque 3.5–4.5  $\mu$ ; cellulis "hülle" crasse tunicatis, irregulariter globosis 12–18  $\mu$  in diam. vel ovoideis ellipticisve 12–15  $\times$  25–30  $\mu$ , massas compactas subsclerotioideas lentissimas magnitudine varias rubo-purpureas formantibus. In culturis e solo, Arkansas, Arizona, et Texas.

Colonies varying markedly upon different media; upon *Czapek's* solution agar rather slow growing, attaining a diameter of 6 to 8 cm. in three weeks at room temperature, plane or somewhat furrowed, mycelium largely submerged and extremely tough, tearing with difficulty, producing numerous dark green, hemispherical to loosely columnar heads in central colony areas, characterized particularly by clusters of irregularly ovoid to elliptical, thick-walled hülle cells (FIG. 3 A and B), at first colorless becoming reddish-purple in age, scattered unevenly or arranged in irregularly concentric zones; reverse colorless at first, becoming dark reddish-purple in age, particularly beneath the hülle masses; odor none. Conidial heads dark dull yellow green to empire green (Ridgway, Pl. XXXII), generally hemispherical to loosely columnar (FIG. 3C), mostly 75 to 125  $\mu$  in diameter. Conidiophores straight or slightly sinuous (FIG. 3D), mostly 250 to 325  $\mu$  in length, occasionally up to 350  $\mu$  by 5.0 to 6.5  $\mu$  in diameter, of approximately uniform diameter throughout, relatively thick-walled, (1.2 to 1.5  $\mu$  in basal portion to 0.8 to 1.0  $\mu$  in terminal area), smooth, tan to light brown in color. Vesicle slightly elongate, the upper hemisphere loosely covered by sterigmata (FIG. 3D), the lower half sterile and often lightly colored, mostly 15 to 20  $\mu$  in diameter. Sterigmata in two series (FIG. 3D), primaries normally 6.5 to 8.5  $\mu$  by 3.5 to 5.0  $\mu$ , secondaries 6.5 to 8.0  $\mu$  by 3.0 to 4.5  $\mu$ , typically bottle-form but commonly much swollen and often quite irregular in form and dimensions. Conidia globose, spinulose, green, mostly 3.5 to 4.5  $\mu$ , rarely larger.



Hülle cells very abundant, thick-walled, irregularly globose, ovoid or elliptical (FIG. 3E), ranging from  $12$  to  $18\ \mu$  in globose cells to  $12$  to  $15\ \mu$  by  $25$  to  $30\ \mu$  in the most elongate bodies, forming compacted masses of indefinite size, extremely tough and in age becoming almost sclerotoid, at first colorless but in age charac-

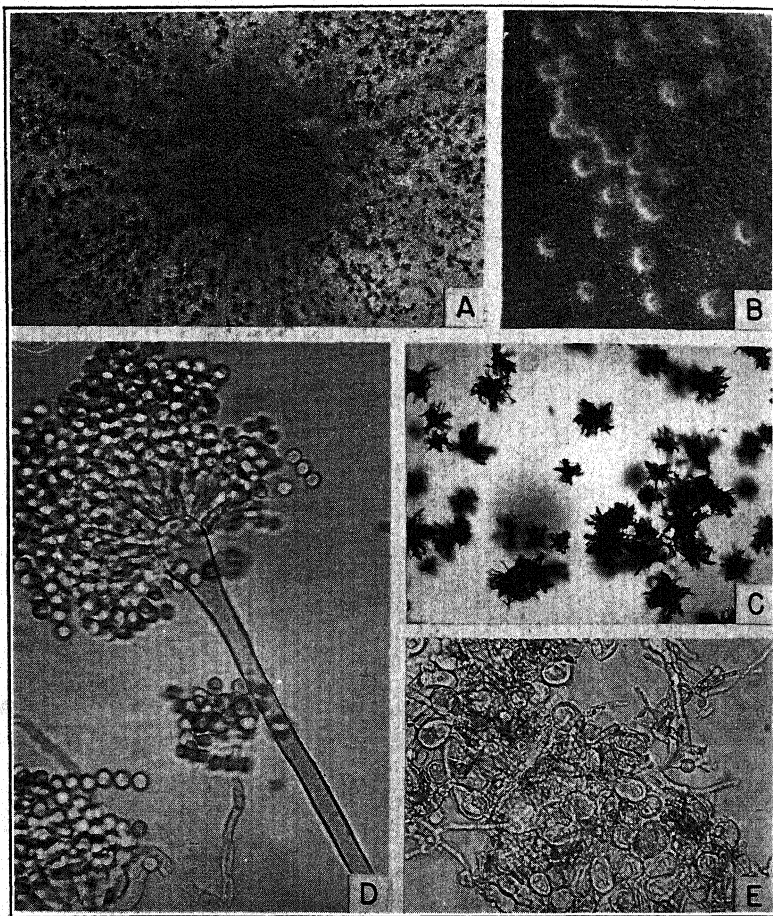


FIG. 3. *Aspergillus caespitosus*; NRRL No. 1929. A, portion of colony on Czapek's solution with 1% liver extract, showing crowded conidial heads in central portion and scattered hülle cell masses in surrounding areas, two weeks old, incubation at room temperature,  $\times 1.8$ . B, portion of colony enlarged showing hülle cell masses,  $\times 10$ . C, silhouettes of conidial heads developed on hay infusion agar,  $\times 48$ . D, typical conidial head showing form of vesicle and arrangement of sterigmata,  $\times 600$ . E, portion of hülle cell mass showing irregular size and form of component elements,  $\times 265$ .

terized by an abundant reddish-purple intercellular pigmentation.

Colonies upon malt agar characterized by a dense stand of erect conidiophores bearing hemispherical to radiate or loosely columnar heads of dark green color approximately empire green (Ridgway, Pl. XXXII) and the complete absence of hülle cells; reverse in light brown shades; odor none. Details of morphology as upon Czapek's solution agar.

Colonies upon hay infusion agar (FIG. 3C) like those upon malt except less heavily sporing.

The binomial *Aspergillus caespitosus* is chosen because of the caespitose character of colonies upon Czapek's solution agar.

Strains examined include NRRL No. 1929 isolated from Arkansas soil collected by F. R. Earle at Fayetteville, Arkansas; NRRL No. 1930 isolated from Arizona soil contributed by C. J. King; and strains isolated from Texas soils contributed by various collaborators.

This species is of particular interest because of its apparent transitional position between the *A. nidulans* group and *A. ustus*. In the character of its stalks, its reddish-purple pigmentation, and in the general color and markings of its conidia it retains the characters of *A. nidulans* and closely related species. In the absence of fertile perithecia and ascospores, the predominantly hemispherical shape of its conidial heads, and in the variable and somewhat irregular form of its hülle cells it is suggestive of the *A. ustus* series. While we are convinced of its intermediate position between the *A. nidulans* group and *A. ustus*, we place it with the former since we believe it is most closely allied to this group. It is believed significant that superficially, cultures of *Aspergillus caespitosus* and *Aspergillus variegatus* (Berk. & Br.) Thom & Raper (6) are strikingly similar upon Czapek's solution agar. This similarity is particularly marked when plates are viewed in reverse since an intense pigmentation marks the under surface of perithecia in the latter species and the under surface of older hülle masses in the former.

#### ***Aspergillus granulosus* sp. nov.**

Coloniae in agaro Czapekii planae vel irregulariter rugulosae, floccosae, alutaceae vel obscure brunneae; capitulis conidicis paucis, plurimum caespitosis, pallide cyaneo-viridibus, hemisphaericis usque radiantibus, 75-125  $\mu$  in diam.; conidiophoris erectis, aseptatis, 350-500  $\times$  5.5-8.0  $\mu$ , membrana

tenui et levi praeditis, ex alutaceo pallide brunneis, saepe infra vesiculas constrictulis; vesiculis ovatis usque ellipticis, membrana tenui praeditis, 12–18  $\mu$  in diam., 15–25  $\mu$  longis, fragilibus, parte maiore sterigmatibus vestitis; sterigmatibus in seriebus duabus, primariis 3.5–5.0  $\times$  3.0–4.0  $\mu$ , secundariis 4.0–5.5  $\times$  3.0–3.5  $\mu$ ; conidiis globosis, pallide viridulis, tenuissime echinulatis, 4.8–5.5  $\mu$  in diam.; cellulis "hülle" abundantibus, irregulariter globosis, ovoideis vel aliquantus elongatis, 12–30  $\mu$  in diam., crasse tunicatis, in cumulos parvos, conspicuos margine coloniae aggregatis et culturas granulosas efficientibus. In culturis e solo, Arkansas, Texas, Arizona, et Costa Rica.

Colonies upon Czapek's solution agar growing well, attaining a diameter of 8 to 10 cm. in two to three weeks at room temperature, plane or irregularly furrowed, predominantly floccose, uneven in texture, buff to dull brown in color from felted sterile mycelia; conidial heads few in number and generally arising from the substratum direct, less often from aerial hyphae, commonly appearing in clusters, pale blue-green in color; colonies characterized particularly by abundant small, colorless clusters of irregularly globose ovoid, or elliptical thick-walled hülle cells which superficially suggest perithecial initials and which in mass give to the colony a semi-granular appearance (FIG. 4 A and B); reverse in shades of dull yellow and brown; slight mushroom odor. Conidial heads few in number, commonly clustered in small groups, most abundant at colony margin, sometimes occurring on tufts of aerial hyphae, hemispherical to radiate, 75 to 125  $\mu$  in diameter, very loose, consisting of comparatively few divergent spore chains (FIG. 4C), approximately pale niagara green in color (Ridgway, Plate XXXIII). Conidiophores erect, straight, non-septate, mostly 350 to 500  $\mu$  in length, 5.5 to 8.0  $\mu$  in diameter, approximately uniform in width throughout, thin-walled, smooth, tan to light brown in color, often slightly constricted just beneath the vesicle. Vesicle ovate to elliptical (FIG. 4D), 12 to 18  $\mu$  in diameter by 15 to 25  $\mu$  in length, thin-walled and easily broken, largely covered by sterigmata. Sterigmata in two series, both comparatively short and stout; primaries 3.5 to 5.0  $\mu$  by 3.0 to 4.0  $\mu$ ; secondaries 4.0 to 5.5  $\mu$  by 3.0 to 3.5  $\mu$ , commonly bottle-form. Conidia globose, pale green, delicately echinulate. Mostly 4.8 to 5.5  $\mu$  in diameter, rarely larger. Hülle cells abundant, irregularly globose, ovoid or somewhat elongate (FIG. 4F), commonly 12 to 30  $\mu$  in long axis, walls heavy, 4 to 5  $\mu$  in thickness, borne primarily in small, colorless clusters which are quite conspicuous at colony margins and lend to them a characteristic granular appearance (FIG. 4 B and E).

Colonies upon malt extract agar showing an accentuation of hülle cell development and a reduction in conidial heads. Otherwise duplicating the cultural picture presented upon Czapek's solution agar.

Colonies upon hay infusion agar thin but broadly spreading, characterized by scattered clusters of hülle cells and erect conidial fructifications giving to the culture a sparse granular appearance.

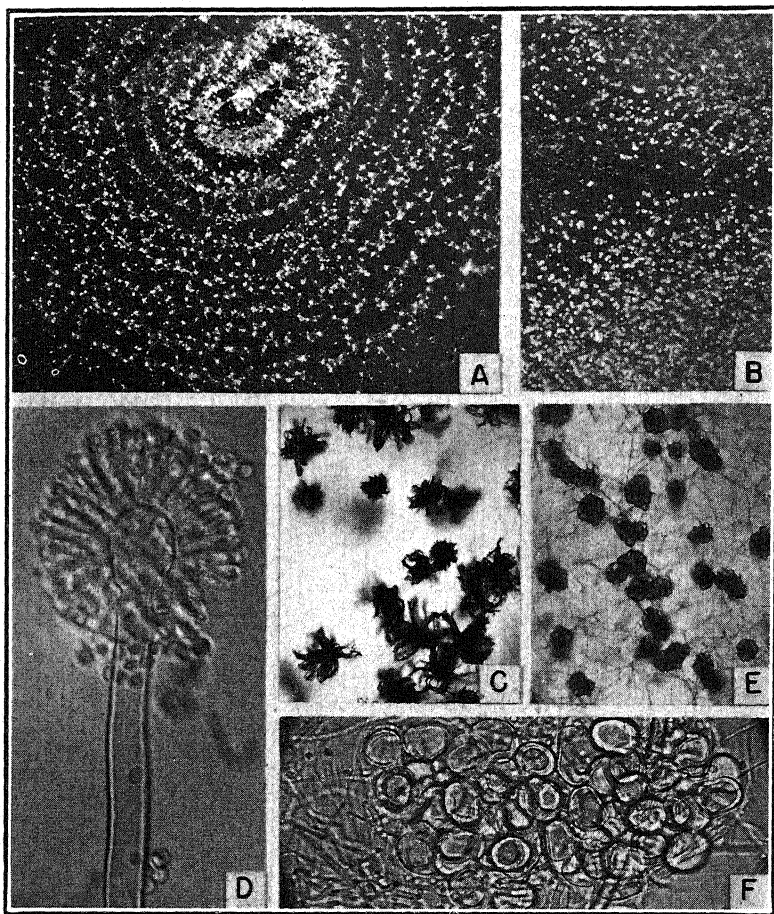


FIG. 4. *Aspergillus granulosis*; NRRL No. 1932. A, portion of colony on hay infusion agar showing clusters of conidial structures and small masses of hülle cells, two weeks old, incubation at room temperature,  $\times 1.5$ . B, portion of marginal area of two colonies on malt extract agar showing characteristic granular appearance resulting from numerous small clusters of hülle cells,  $\times 1.5$ . C, silhouettes of conidial heads,  $\times 48$ . D, conidial head showing slightly elongate vesicle, sterigmata in two series, and constriction in conidiophore just beneath the vesicle,  $\times 750$ . E, small clusters, or "granules," of hülle cells,  $\times 48$ . F, double cluster of hülle cells, much enlarged,  $\times 265$ .

The binomial *Aspergillus granulosus* is chosen because of the conspicuous granular appearance of the colonies produced upon most laboratory substrata.

Type culture NRRL No. 1932 was isolated in September 1942, from a sample of soil collected in Fayetteville, Arkansas, and contributed by Mr. F. R. Earle. Additional strains have been isolated from soils collected in Texas, Arizona, and Costa Rica. It is believed common in soils characterized by a warm temperature during part or all of the year.

Different strains vary materially in the number of conidial heads produced upon common laboratory media such as Czapek's solution and malt extract agars, ranging from abundant heads in some to only widely scattered heads in others. All fruit reasonably well, however, upon hay infusion agar, the medium upon which all original isolations were made.

The brown color of the conidiophores, the presence of ovoid to somewhat irregular hülle cells, and the green color of its conidia ally this species with *A. ustus*. It differs markedly from the more common representatives of this group, however, in the lighter and persistently green color of its conidia, the small clusters rather than irregular masses of hülle cells, and in possessing somewhat more elongate vesicles. In this latter character it suggests *Aspergillus flavipes* but is in turn excluded from this group by the green color of its spores.

### ***Aspergillus panamensis* sp. nov.**

Coloniae in agaro Czapekii pertenuae, paene totae submersae, fructificationes conidicas late dispersas capitulis radiantibus pallide brunneis gerentes, in agaro maltoso luxurianter fructificantes, rubro-brunneae; capitulis radiantibus, pallide brunneis, typice globosis, 250–450  $\mu$  in diam., ex avellaneo rubro-brunneis; conidiophoris rectis, 600–900  $\times$  9–12  $\mu$ , membrana comparative crassa praeditis, levibus; vesiculis hyalinis, membrana tenui praeditis, globosis vel subelongatis, 25–30  $\mu$  in diam., totis fertilibus; sterigmatibus in seriebus duabus, dense compactis, primariis 5.5–6.5  $\times$  2.4–2.8  $\mu$ , secundariis 5–6  $\times$  1.5–2  $\mu$ , conidiis in massa pallide flavo-brunneis, globosis usque subglobosis, levibus, 2.2–2.6  $\mu$  in diam. In culturis e solo, Panama.

Colonies upon Czapek's solution agar after two weeks at room temperature very thin, consisting of a sparse and transparent growth of vegetative hyphae, almost wholly submerged, bearing widely scattered, erect conidial structures with radiate heads (FIG. 5A), light brown in color. Colonies upon malt extract agar at

room temperature growing well and fruiting luxuriantly (FIG. 5B), reddish-brown in color, consisting of a dense, predominantly red basal mycelium from which develops massed conidial structures, often in broken or continuous concentric zones; fertile

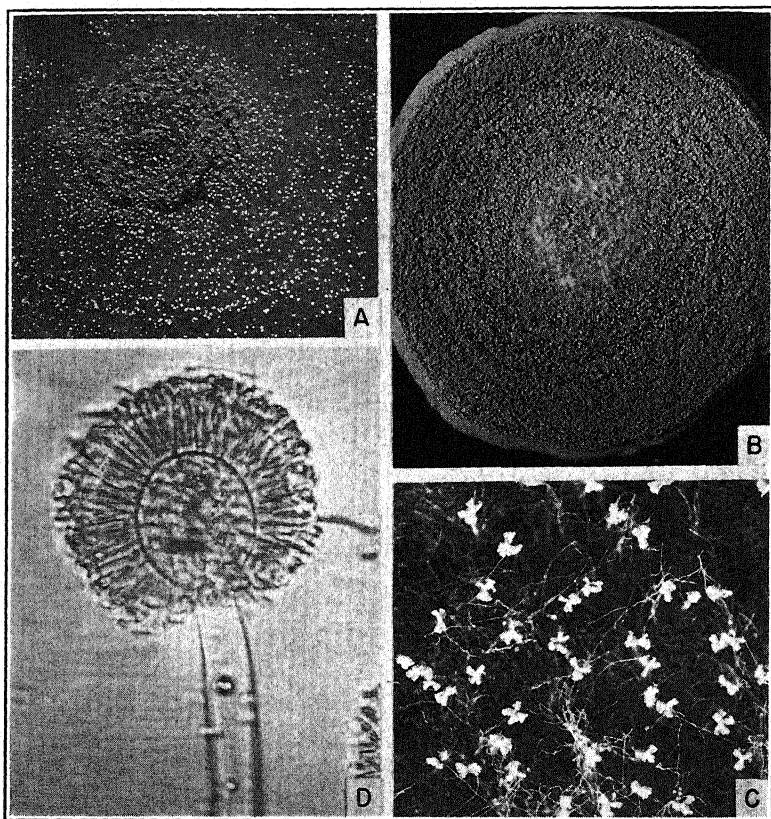


FIG. 5. *Aspergillus panamensis*; NRRL No. 1785. A, portion of a single colony on Czapek's solution agar with 1% liver extract showing limited growth and scattered conidial heads, 2 weeks old, incubation at room temperature,  $\times 1.5$ . B, luxuriant growth and heavily sporing colony on malt extract agar, age and incubation as in preceding,  $\times 1.5$ . C, conidial heads showing characteristic forms when mature, hay infusion agar,  $\times 8$ . D, single conidial head showing almost globose vesicle, closely packed, double sterigmata,  $\times 500$ .

conidiophores bearing globose to radiate heads, light brown in color, near wood brown of Ridgway (Pl. XL), these, together with red-colored sterile structures and aerial hyphae give the colony its characteristic appearance and color; in age, colonies tending to



develop a loose floccose overgrowth, more or less obscuring the abundant conidial heads; reverse dull brown; odor none. Colonies upon hay infusion agar spreading broadly, thin, largely submerged, giving rise to scattered, erect conidial structures commonly arranged in concentric zones; heads radiate, dull brown in color. Conidial structures arising directly from the substratum, scattered or abundant depending upon the culture medium employed. Heads typically globose, in age characterized by loosely radiating chains of conidia, or by few to several roughly columnar masses, (FIG. 5C), variable in size, commonly ranging from 250 to 450  $\mu$  in diameter, occasionally up to 500  $\mu$ , varying in color from avellaneous to wood brown (Ridgway, Pl. XL) to Saccardo's umber (Ridgway, Pl. XXIX). Conidiophores straight, mostly 600 to 900  $\mu$  in length by 9 to 12  $\mu$  in diameter, occasionally larger; walls smooth, comparatively heavy, ranging from 3 to 3.5  $\mu$  thick in the basal area to 1.5 to 2  $\mu$  in the terminal area, approximately uniform in diameter throughout except for a limited reduction immediately beneath the vesicle. Vesicle colorless, comparatively thin-walled, globose or slightly elongate (FIG. 5D), mostly 25 to 30  $\mu$  in diameter, fertile over the entire area. Sterigmata in two series, closely packed, primaries 5.5 to 6.5  $\mu$  by 2.4 to 2.8  $\mu$ , secondaries 5 to 6  $\mu$  by 1.5 to 2  $\mu$ . Conidia light yellowish-brown in mass, globose to subglobose, smooth-walled, mostly 2.2 to 2.6  $\mu$  in diameter, occasionally 2.8  $\mu$ .

The binomial *Aspergillus panamensis* is chosen because of the place of species origin.

Type culture NRRL No. 1785 was isolated in January 1942, from Panama soil collected in the summer of 1941 by Mr. John T. Bonner. A second culture, NRRL No. 1786, differs from the above strain in minor details but clearly belongs with it. This was isolated from a different sample of Panama soil collected by Bonner.

The species is believed to represent a member of the *Aspergillus wentii* group with possible close affinity to *Aspergillus niger* mut. *cinnamomeus*<sup>3</sup> (syn. *Aspergillus cinnamomeus* Schiemann) and *Aspergillus niger* mut. *Schiemanni*<sup>4</sup> (syn. *A. fuscus* Schiemann). While it bears a certain resemblance to these forms in the com-

<sup>3</sup> Nomenclature according to Thom and Raper—"Manual of The Aspergilli," now in preparation.

<sup>4</sup> Nomenclature according to Thom and Raper—"Manual of The Aspergilli," now in preparation.

paratively light color of its conidial heads and in the smallness and general character of its conidia, it differs from these forms in three very striking particulars. (1) It characteristically develops an extensive red-colored aerial mycelium upon media such as malt extract agar where it attains its maximum growth; (2) it grows very sparsely upon Czapek's solution agar, upon which the above noted forms grow luxuriantly; and (3) it possesses very small primary sterigmata, measuring  $5.5$  to  $6.5 \mu$  by  $2.4$  to  $2.8 \mu$  in contrast to  $15$  to  $18 \mu$  by  $3$  to  $5 \mu$  for mut. *cinnamomeus* and  $15$  to  $40 \mu$  by  $4$  to  $6 \mu$  for mut. *Schiemanni*. Whether or not the species actually represents a naturally occurring mutation from *A. niger* can only be guessed. The smallness of its conidia and primary sterigmata would hardly support this hypothesis. In cases where color mutations have been obtained from known cultures, the dimensions of specific structures in such mutations generally agree very closely with those of the same structures in the parent strain; and black *Aspergilli* with the dimensions of *A. panamensis* are rarely, if ever, encountered in nature. The possibility of this representing a mutation is not excluded, but until additional evidence supporting such origin is forthcoming, the writers feel warranted in describing as new this unique form which obviously is able to maintain itself in the soils of Panama.

The luxuriant growth of the fungus upon malt extract agar and its very sparse development upon Czapek's solution agar is strongly suggestive of other cultures which we have found to possess vitamin deficiencies or an inability to utilize nitrate nitrogen. In this species, however, the paucity of growth upon our standard Czapek's agar appears to result from an absence or inadequacy of invertase production since it grows well and fruits quite abundantly upon Czapek's solution containing glucose instead of sucrose. In the presence of other microorganisms capable of reducing sucrose, the fungus grows well and fruits abundantly upon Czapek's solution agar.

A recurring phenomenon typical of this species is the manner in which massed conidiophores develop in broken or continuous concentric zones in the growing colony upon malt extract and other favorable media. Particularly characteristic is the failure of great numbers of these conidiophores to produce fertile heads and the



lateness with which others develop such reproductive structures. While no suggestion of close relationship is intended, these sterile structures bear a certain superficial resemblance to the "spears" characteristic of *Aspergillus unguis* (Emile-Weil & Gaudin) Emnd. Thom & Raper as described by Thom and Raper (6).

Strain NRRL No. 1876, likewise isolated from Panama soil, differs from the type in producing somewhat more restricted colonies. These are, in addition, less highly colored, due primarily to a reduction in the amount of red colored vegetative hyphae and in the number of aborted conidiophores. It is similar to it, however, in all basic morphological characteristics, and, like it, makes a very sparse growth upon Czapek's solution agar containing sucrose but grows well and fruits luxuriantly upon malt extract agar and Czapek's agar containing dextrose.

#### ***Aspergillus sparsus* sp. nov.**

Coloniae in agar Czapekii late crescentes, griseo-brunneae, primum submersae dein aerae, fructificationibus conidicis erectis, late dispersis, viridialutaceis, in agar ex infusione foeni sparsis, conspicuis, saepe concentricae zonatis, capitulis globosis vel radiantibus vel irregulariter scindentibus, 200–250  $\mu$  in diam.; conidiophoris rectis, 1–1.5 mm. longis, 10–12  $\mu$  latis, conspicue echinulatis, saepe infra vesiculas abrupte attenuatis; vesiculis membrana comparative tenui praeditis, globosis, plerumque 40–50  $\mu$  in diam., totis fertilibus; sterigmatibus in seriebus duabus, dense confertis, primariis vulgo 8–10  $\times$  3–5  $\mu$ , secundariis 6–8  $\times$  2.5–3.5  $\mu$ ; conidiis in massa pallide flavidulis, subglobosis usque ellipticis, minute asperulis, plerumque 3–3.5  $\mu$ . In culturis e solo, Honduras et Texas.

Colonies upon Czapek's solution agar at room temperature spreading broadly, dull grayish-brown in color, at first largely submerged but later developing limited aerial growth, giving rise to widely scattered erect conidial structures characterized by dull greenish-tan heads that do not affect the color of the colony as a whole; reverse in brown shades; odor none. Colonies upon Czapek's solution agar with 20 per cent sugar slightly heavier sporing (FIG. 6A). Conidial structures erect, arising from a submerged mycelium; heads typically globose radiate to splitting irregularly in age (FIG. 6B), mostly 200 to 250  $\mu$  in diameter, occasionally as much as 500  $\mu$ , pale olive-buff to olive-buff (Ridgway, Pl. XL) upon Czapek's and hay infusion agars to pale olive or olivine (Ridgway, Pl. XXXII) upon malt extract agar. Conidiophores straight, mostly 1 to 1½ mm. in length by 10 to 12  $\mu$  in diameter, approximately uniform in diameter throughout, walls 1.2 to 1.5  $\mu$  in thickness, conspicuously roughened, typically

arising from foot cells enmeshed in a network of "feeder" hyphae, often tapering abruptly in the region immediately beneath the vesicles (FIG. 6 C and D). Vesicles comparatively thin-walled, globose, mostly 40 to 50  $\mu$  in diameter, occasionally larger or smaller, bearing sterigmata over the entire surface (FIG. 6C). Sterigmata in two series, crowded, comparatively short and stout,

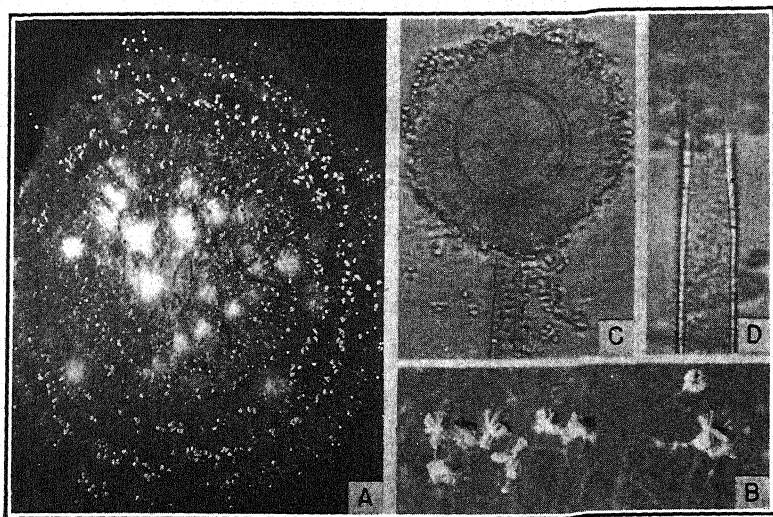


FIG. 6. *Aspergillus sparsus*; NRRL No. 1933. A, single colony on Czapek's solution agar with 20% sucrose showing limited growth and scattered conidial heads, 2 weeks old, incubation at room temperature,  $\times 1.5$ . B, conidial heads, showing characteristic splitting, and the generally loose arrangement of conidial chains,  $\times 8$ . C, conidial head showing globose vesicle, closely packed, double sterigmata and terminal portion of roughened conidiophore,  $\times 400$ . D, further enlargement of conidiophore showing characteristic echinulations,  $\times 650$ .

primaries commonly 8 to 10  $\mu$  by 3 to 5  $\mu$ , secondaries 6 to 8  $\mu$  by 2.5 to 3.5  $\mu$ . Conidia pale yellowish in mass, individually showing slight coloration, subglobose to slightly elliptical, very finely roughened, mostly 3 to 3.5  $\mu$  in long axis.

Colonies on hay infusion agar spreading broadly, almost wholly submerged, giving rise to scattered but conspicuous conidial structures, often in definite concentric zones; heads globose, radiate, in olive-buff shades. Colonies upon malt extract agar spreading irregularly, floccose, 1 to 2 mm. deep. cream-buff in color; conidial structures very few in number. heads globose, radiate, dull yellow-green in color.

The binomial *Aspergillus sparsus* is chosen for this species because of its characteristic sparse production of conidial structures upon all substrata employed.

Type culture NRRL No. 1933 was isolated in February 1943, from soil collected in La Lima, Honduras, by Dr. L. A. Underkofler in December 1942. A second strain, NRRL No. 1937, which duplicates the type almost exactly was subsequently isolated from soil collected in Bixar County, Texas, by Sister Mary Clare of Our Lady of the Lake College, San Antonio, Texas.

The correct position of this species within the genus *Aspergillus* is open to question. The presence of a colored, coarsely roughened stalk indicates close relationship with *Aspergillus ochraceus*. This is likewise supported by the globose vesicle and head, although these characters are typical of other groups as well. The scarcity of fruiting structures upon all media, and more particularly the greenish tint of the spore masses, however, tend to set it apart from the common representatives of this great group. The general habit of the colonies, together with the paucity of conidial structures, is strongly suggestive of *Aspergillus alliaceus*, but this latter species does not show any green color in its conidial heads; it possesses smooth, colorless conidiophores; and upon ordinary culture media regularly produces an abundance of black sclerotia which very often dominates and characterizes the culture. In the color and character of its conidial heads it is somewhat suggestive of George Smith's new species, *A. avenaceus* (3) but it differs from this fungus as it does from *A. alliaceus* in possessing rough conidiophores and in its failure to produce sclerotia. Until additional related forms are isolated, we believe it best to consider this species as a member of the *Aspergillus ochraceus* group, realizing that it does not entirely fit this placement as the group has hitherto been considered.

#### SUMMARY

Five species and one variety of *Aspergillus* are described as new. All of these forms were isolated from southern or tropical soils and are believed to represent normal components of the microfloras of the areas from which they were obtained.

The new forms include:

(1) *Aspergillus janus*, characterized by conidial structures of two types, namely, white heads with clavate vesicles borne upon

long conidiophores, and blue-green heads with globose to ovate vesicles borne upon short conidiophores. This species is believed closely related to *Aspergillus Sydowi* (Bainier) Thom & Church.

(2) *Aspergillus janus* var. *brevis*, differing from the species in the smaller dimensions of both white and green heads and in the marked tendency for colonies to develop alternate radial sectors of white and green heads in approximately pure stands.

(3) *Aspergillus caespitosus*, a non-ascosporic member of the *A. nidulans* group, characterized by irregular masses of hülle cells and non-columnar heads.

(4) *Aspergillus granulosus*, a member of the *A. ustus* group, characterized by small clusters ("granules") of hülle cells and a limited production of pale blue-green conidial heads.

(5) *Aspergillus panamensis*, a form suggestive of the *A. niger* group but characterized by avellaneous to dull brown conidial heads and an apparent invertase deficiency.

(6) *Aspergillus sparsus*, a member of the *A. ochraceus* group, characterized generally by limited growth and the production of few conidial structures, with conidiophores strongly echinulate and globose heads approximately olive-buff in color.

#### ACKNOWLEDGMENT

The writers are greatly indebted to Miss Edith K. Cash for preparing the Latin diagnoses, to Mrs. Dorothy F. Alexander for assistance in cultural studies and in the preparation of illustrations, and to our collaborators who collected and sent to us the soils from which these fungi were isolated.

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## A STUDY OF THE APPLE ROT FUNGUS *PHIALOPHORA MALORUM*

L. P. MCCOLLOCH

(WITH 4 FIGURES)

In a preliminary note (9) the author discussed briefly a rot of stored apples and pointed out that the fungus causing the rot should be properly designated as *Phialophora malorum* (Kidd & Beaum.) McCulloch, with *Sporotrichum carpogenum* Ruehle as a synonym. The serious losses occasioned by this fungus have warranted further studies and an account will be given here in greater detail of its physiology, morphology and taxonomy.

*Phialophora malorum* is primarily a saprophyte living in the surface soil and upon the bark and in cankerous woody tissue of apple trees in the orchard. Apples become infected while on the trees and under favorable conditions the fungus develops and causes serious and unpredictable losses in fruit in storage. The majority of lesions occurring on Winesap apples appear to develop around the lenticels, yet it is difficult to determine in many cases whether the point of entrance is through a lenticel or through cuticular cracks. The fungus also enters through insect injuries and mechanical punctures.

### SOURCE OF CULTURES

Many cultures were made from decayed areas in stored apples from Virginia over a period of three years and occasional cultures were made from decayed apples grown in Maryland and Washington. In addition others were obtained from cankerous wood of apple trees and surface soil from Virginia during September 1937 and February 1939. The Centraal Bureau voor Schimmelcultures, Baarn, Holland, supplied a culture of Kidd and Beaumont's "*Sporotrichum malorum*" and the Botany Department of Washington State College, one of Ruehle's "*Sporotrichum carpogenum*." A transfer of *Phialophora verrucosa* Medlar was furnished by Dr. Charles Thom and three wood staining species, *Phialophora fasti-*

*giata* (Lager. & Melin) Conant, *P. brunnescens* (Davidson) Conant, and *P. repens* (Davidson) Conant, were obtained from Ross W. Davidson of the Division of Forest Pathology, Bureau of Plant Industry.

Single-spore cultures were obtained from all of the isolates made by the author as well as from several cultures received from other sources. Sub-cultures were periodically set up from the single spore lines, using spores and bits of mycelium taken from the central part of the old culture. Stock cultures were carried on Thaxter's agar. As a preliminary step all isolates were tested on fruit to determine the extent of pathogenicity and only those found to produce apple decay were included in the general study.

After preliminary studies of the entire group of cultures, ten representatives were selected for more detailed study. The sources of the ten cultures included in the study are listed in table 1.

TABLE 1  
SOURCES OF THE 10 STRAINS OF PHIALOPHORA MALORUM INCLUDED IN  
THE DETAILED STUDY

Serial number of culture	Source of cultures
92	<i>Sporotrichum malorum</i> (Kidd & Beaum.) Centraal Bureau voor Schimmelcultures, Baarn, Holland
90	<i>Sporotrichum carpogenum</i> Ruehle, Botany Department, State College, Pullman, Washington
128	Isolated from fruit lesion, Winesap apple, from Virginia
132	Isolated from fruit lesion, Winesap apple, from Virginia
158	Isolated from fruit lesion, Winesap apple, from Virginia
159	Isolated from fruit lesion, Winesap apple, from Virginia
163	Isolated from fruit lesion, Winesap apple, from Virginia
172	Isolated from fruit lesion, Winesap apple, from Virginia
186	Isolated from soil beneath Winesap tree, from Virginia
231	Isolated from cankerous area on Winesap tree, from Virginia

#### CULTURAL STUDIES

The several cultures grew well, but slowly, on most of the nutrient media tried. The extent of aerial development and the color of the mycelial mats were greatly influenced by the nutrients supplied in the artificial media. Development on water agar was scant, but the hyphae developed a smoky color. Heineman's asparagin-peptone agar with washed starch as the carbohydrate

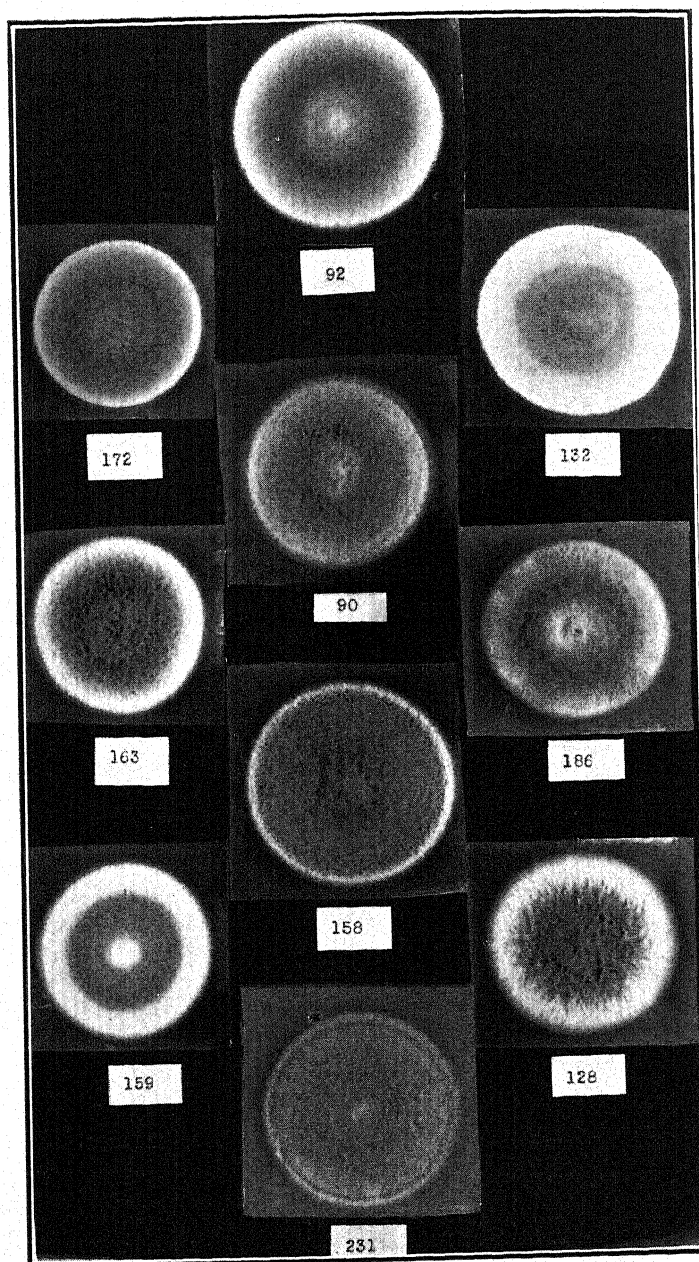


FIG. 1. General appearance of *Phialophora malorum* strains on Thaxter's agar.

source greatly retarded the development of the fungi. The fungus mats were wet, appressed and without aerial hyphae during the first ten days of growth. After eighteen days at room temperature, cultures 90, 92, 159, and 163 had failed to produce dark pigment; cultures 128 and 158 had developed a brown pigment; while 132, 172, 186 and 231 approached the normal degree of color. The rate of growth on Czapek's agar was fairly normal, but the mats were wet and appressed in all except No. 132 which was velvety, and 172 which was woolly instead of having the usual velvety texture. There was a great variation in the ability of these organisms to produce dark pigment on this medium. Cultures 159 and 163 remained a dingy white or yellowish white after 20 days at room temperature. Thaxter's agar, composed of unoxidized potato juice and two per cent dextrose, induced better development than other plant decoctions or synthetic media tested. The cultures responded so well on this medium (FIG. 1) that numerous observations were made on the form, texture, and mass color of the fungus mat, notwithstanding the fact that such a medium cannot be accurately duplicated. The color of the organisms varied on each medium (table 2), but Thaxter's medium with five per cent of agar noticeably unified the coloring, as compared with the same medium with 1.5 per cent of agar.

#### INFLUENCE OF HYDROGEN-ION CONCENTRATION

A study was made of the ten cultures, using beef infusion broth with hydrogen-ion concentrations from pH 8.35 to pH 2.5. Germination occurred at pH 3.5 after 24 hours, and after a longer period of time at pH 2.9 and pH 2.5. After seven days at room temperature, the extent of growth was noted and pH readings were made to determine the extent to which the hydrogen-ion concentrations had been changed by the fungus development.

The data showed individual differences in the reaction of the fungi at a given concentration but they all decreased the hydrogen-ion concentration from that originally used. Judging from the extent of growth and the change in hydrogen-ion concentration, the best development occurred between pH 4.4 and 6.0 which is in agreement with Gardner's (3) spore-germination studies.



TABLE 2  
COLOR AND TEXTURE OF 10 STRAINS OF PHIALOPHORA MALORUM ON TWO TYPES OF CULTURE MEDIA

Serial no.	On Thaxter's 2 per cent agar		On 1.5 per cent Difco malt agar	
	Color of mycelial mat according to Ridgway's color standards	Texture	Color of mycelial mat according to Ridgway's color standards	Texture
92	Uniform color—nearest to dark olive gray	Compact woolly	Central area, grayish olive; outer part, mineral gray Pale gull gray to gull gray	Compact woolly Open woolly, surface coarse webby
90	Uniform color—between deep olive and dark olive gray	Compact woolly		
128	Uniform color—between deep olive and dark olive gray	Spinose	Light olive gray	Spinose, becoming webby
132	Three color bands: center, light grayish olive; mid-portion, nearest smoke gray; margin, pale smoke gray	Dense, fine velvety	Center, light olive gray; remainder, pale drab gray	Dense, fine velvety
158	Uniform color—between deep olive and dark olive gray	Open woolly	Light olive gray to olive gray	Open woolly
159	Uniform color—deep olive gray	Dense woolly	Pale olive gray	Dense, compact woolly
163	Uniform color—light grayish olive	Open woolly	Light grayish olive	Open woolly
172	Two color bands: center, deep grayish olive; outer, between light grayish olive and grayish olive	Dense, fine velvety	Central part, light drab; remainder, light olive gray	Dense, fine velvety
186	Uniform color—nearest to dark grayish olive	Soft woolly	No reading made	Wet, appressed
231	Uniform color—nearest to deep olive	Soft woolly	Light olive gray	Dense, compact woolly

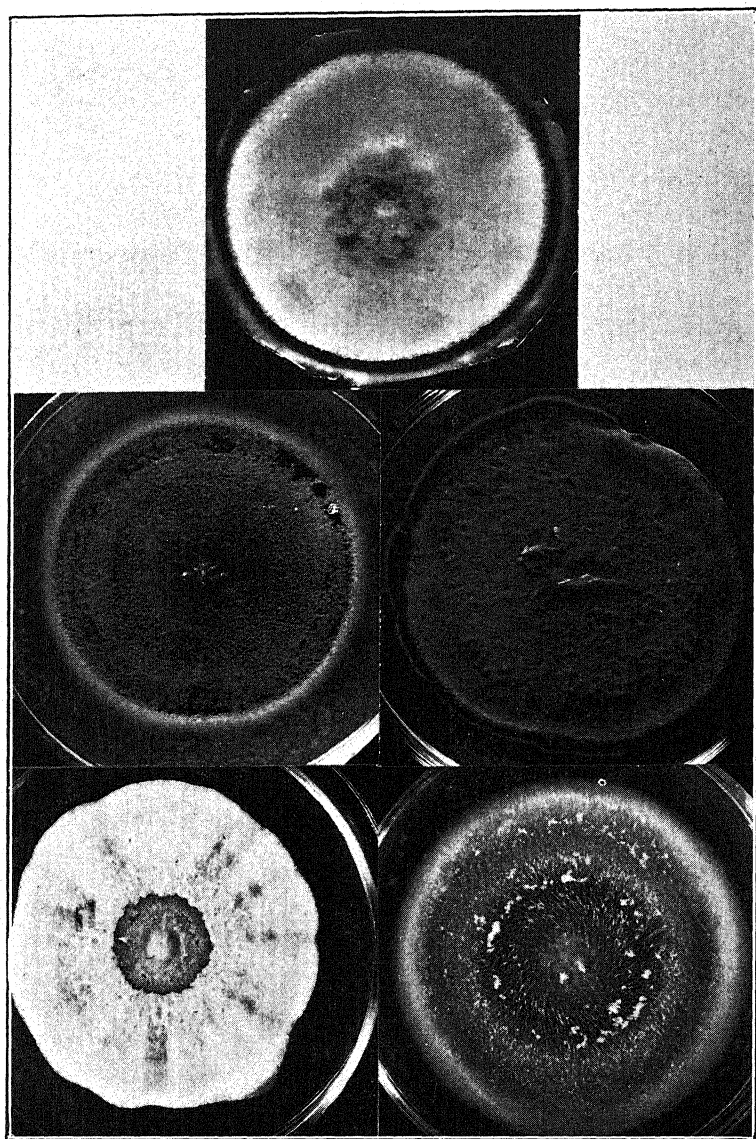


FIG. 2. Culture No. 90 at top center with four of its saltants shown below.

## OXIDASE REACTION

The method used in testing the cultures for oxidase production was the same as that described by Davidson (1), using .5 per cent tannic acid with 1.5 per cent Difco malt, and .5 per cent gallic acid with 1.5 per cent Difco malt, each made up with 2 per cent agar. The cultures were incubated at room temperature. The diameter of the fungus colony, and the browned area caused by the oxidation of the acids were measured periodically to show the rate of development.

The fungus reaction to these media varied more in the first four days than after 14 days or longer. Eventually, all cultures gave positive oxidase reaction on tannic acid medium. Likewise all cultures except No. 158 gave positive reactions to gallic acid medium, although there was considerable difference in the rate and intensity of oxidase production.

## ACID PRODUCTION

In testing for the production of acid, a synthetic medium using glycerine as the carbohydrate source was adjusted in pH 7.0, and bromcresol purple was added as an indicator. On the eighth and ninth days at room temperature, measurements were made of the

TABLE 3  
RATE AND EXTENT OF ACID PRODUCTION BY 10 STRAINS OF PHIALOPHORA  
MALORUM WHEN GROWN ON A SYNTHETIC MEDIUM CONTAINING  
BROMCRESOL PURPLE AND ADJUSTED TO pH 7.0

Culture number	After 8 days			After 9 days		
	Diameter in mm.		Difference	Diameter in mm.		Difference
	Fungus colony	Yellow zone		Fungus colony	Yellow zone	
92	23.0	31.5	8.5	26.0	39.5	13.5
90	23.0	24.0	1.0	26.5	28.5	2.0
128	22.0	34.0	12.0	27.0	44.0	17.0
132	20.0	22.0	2.0	22.0	31.0	9.0
158	24.0	34.0	10.0	28.0	45.0	17.0
159	23.0	26.0	3.0	25.0	33.0	8.0
163	18.0	25.0	7.0	20.0	32.0	12.0
172	19.0	trace	trace	24.0	trace	trace
186	19.0	trace	trace	22.0	28.0	6.0
231	21.0	27.0	6.0	24.0	35.0	11.0

diameter of each fungus colony and of the diameter of the yellow, acid zone extending beyond the fungus colony (table 3).

#### SALTATION TENDENCIES

Variations found in the color, texture, rate of growth, and general physiological behavior of the isolates are evidence of their unstable nature. This conclusion is based upon observation of saltations in some of the isolates. Of the ten cultures studied in detail, No. 90 proved more unstable than the others, or at least the saltants produced by this culture were more obvious. While single-spore cultures were made for all of the isolates as they were acquired, subsequent sub-cultures were maintained by mass transfer of hyphae and spores. It seems probable that less variation would develop in cultures propagated in this manner than in cultures from single spores.

Saltation occurred in culture No. 90 at room temperature when growing on Thaxter's agar. There was a definite wedge-shaped sector of pale gray in the normally dark colony. This pale gray form has been maintained through mass transfer and in only one instance has it appeared unstable in culture. In one sub-culture a sector developed which was darker than the pale form, but not as dark as the parent form. Single-spore cultures from the parent culture were again made and a number of single-spore colonies were observed, all of which were typical of the parent culture.

Reisolations from apple lesions resulting from artificial inoculation, made with a spore suspension from culture No. 90, yielded two cultures that were pale. Single-spore cultures were obtained from these isolates. One remained stable and the other developed a dark sector partially reverting to the parent culture type.

Single-spore cultures were again made from the parent culture. The spores were seeded thinly in the agar and allowed to develop into visible colonies before transferring. An effort was made to select colonies which appeared unlike, and four such colonies were planted in the same petri dish. Two of these colonies were typical of the parent. The third colony was typical in color but of a different texture. The fourth colony appeared abnormal. It had very scant aerial hyphae, the surface being covered by short

upright hyphae, and the general pattern of growth consisted of radiating hyphae with concentric bands.

The instability of culture No. 90 resulted in nine strains which showed certain variations from the parent form. Four of these that differed most are shown in figure 2. Variations in physiological behavior were noted in rate of growth, form, texture, and amount of dark pigment in the fungus colony, and in extent of oxidase production on tannic acid medium. Only one strain varied markedly from the others in the size of the conidia.

These various physiological tests were carried on in an effort to ascertain whether any basis could be found for dividing the isolates into permanent groups, specific or otherwise. Occasionally two or more isolates appeared to be alike or similar in form and behavior. For the most part, however, there were slight variations only which make the group one large series showing gradual variation between extremes that were rather distinct in color, appearance and behavior.

The factors that caused these isolates to have more or less individual differences in appearance, whether due to nuclear fusion somewhere in development or to other unknown causes, seem to have likewise caused the variations in their physiological behavior. This has been demonstrated in the case of the saltants that arose in culture from single-spore isolates. This physiological variation is linked in some way with the ability of the respective strains to assimilate given nutrient media.

It is concluded from the study of the various isolates in general and of the variations found in culture 90 that all may be considered merely as strains of the one species *Phialophora malorum*.

#### MORPHOLOGY

Considerable variation has been found among the isolates in the texture of the mycelial mat and general appearance in culture. There were likewise differences in the details of hyphal appearance, intensity of color, abundance of conidia and mucous production, size and shape of the phialides and conidiophores, distinctness of the phialide cup and the shape and behavior of the conidia. In some of the isolates the cup was so thin that it was very difficult to discern. In such instances the conidia were no

doubt freed in such manner that there were relatively few torn fragments of membrane at the point of separation.

The isolates included in the detailed study are representative of the large group as a whole. They are basically alike in morphology, especially when observed during the young stages of growth. By comparing the range in size of the conidia (table 4) it is found that a greater variation in size exists within a given isolate than between isolates.

TABLE 4  
RANGE IN SIZE OF CONIDIA FOUND IN 10 STRAINS OF PHIALOPHORA  
MALORUM GROWN ON THAXTER'S AGAR

Serial no.	Source of cultures tested	Range in size of conidia
92	<i>Sporotrichum malorum</i> Kidd & Beaumont	4.2-7.8 $\mu$ $\times$ 1.4-3.6 $\mu$
90	<i>Sporotrichum carpogenum</i> Ruehle	3.6-8.4 $\mu$ $\times$ 1.8-3.6 $\mu$
128	Isolated from fruit lesion—Winesap apple	4.8-7.2 $\mu$ $\times$ 1.4-3.6 $\mu$
132	Isolated from fruit lesion—Winesap apple	3.6-7.2 $\mu$ $\times$ 1.2-2.4 $\mu$
158	Isolated from fruit lesion—Winesap apple	3.0-7.2 $\mu$ $\times$ 1.2-2.4 $\mu$
159	Isolated from fruit lesion—Winesap apple	4.8-9.6 $\mu$ $\times$ 1.2-2.4 $\mu$
163	Isolated from fruit lesion—Winesap apple	3.6-9.6 $\mu$ $\times$ 1.2-3.6 $\mu$
172	Isolated from fruit lesion—Winesap apple	3.6-8.4 $\mu$ $\times$ 1.2-3.0 $\mu$
186	Isolated from soil beneath Winesap tree	4.8-7.2 $\mu$ $\times$ 1.8-3.0 $\mu$
231	Isolated from cankerous area on Winesap tree	3.6-7.8 $\mu$ $\times$ 1.2-2.4 $\mu$

Certain other morphological details have been discussed by Gardner (4), but details of the process of conidial formation do not appear to have been previously included.

The conidia are extruded from single, terminal, sporogenous cells which Mason (8) has defined as phialides (FIG. 3). Typical phialides found in this fungus are short, one-celled, ampulliform, but often unsymmetrical structures. They are swollen through the center, tapering at the base, with a constricted neck and a flared cup at the apex, through which the conidia are formed. The sporogenous cell does not always conform to the above type description, but regardless of shape, the process of sporulation is the same. The first indication of sporulation is the constriction and elongation of the phialide apex. The first conidium formed ruptures the terminal wall of the phialide which apparently has been under tension, and the conidium is cut off and extruded from the phialide. The ruptured end of the phialide is held in the

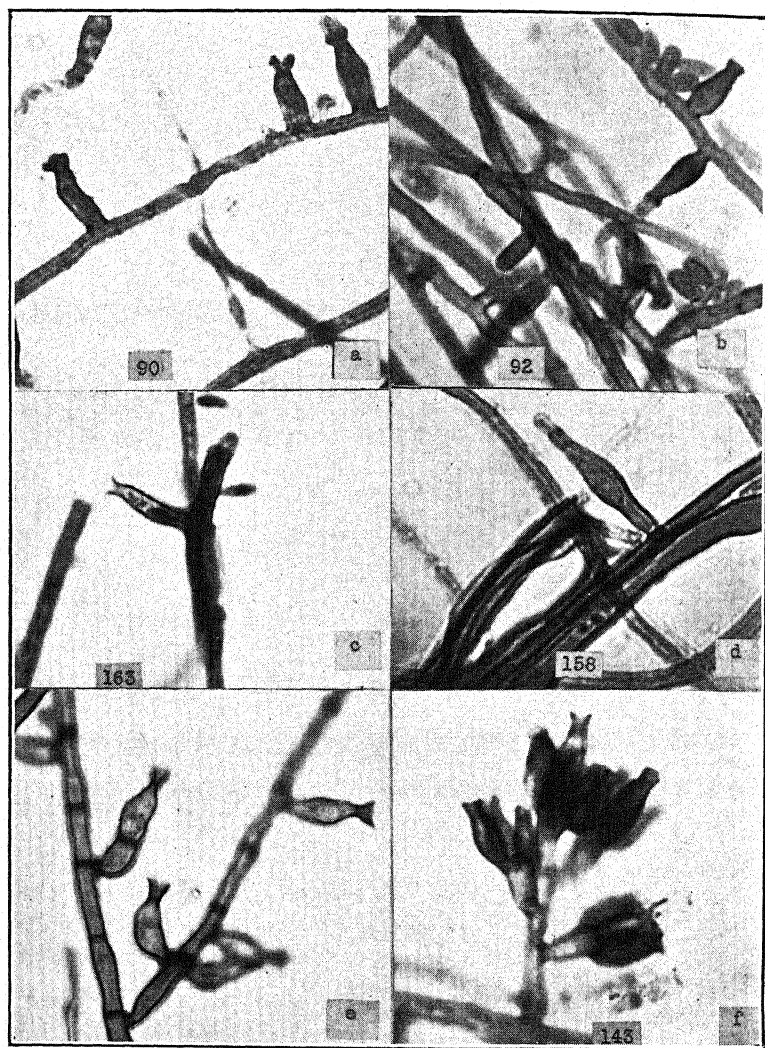


FIG. 3. A comparative study of phialides; magnification  $1900\times$ ; a, b, c, d and f, strains of *Phialophora malorum*; e, *Phialophora verrucosa*.

shape of a cup by the formation of succeeding conidia, and eventually becomes rigid.

In the normal process, the conidia are never borne within the phialide. The study of stained mounts revealed a pore situated at the base of the cup. It is through this pore that the conidia are



FIG. 4. Phialides of *Phialophora malorum*, greatly enlarged, showing the strands of protoplasm from the sporogenous cells to the developing conidia.

formed. The protoplasm from the mother cell within the phialide, surrounded by a membrane, grows out through the pore and the developing conidium, seated in the open cup grows to maturity (FIG. 4). Thaxter described this process as a proliferation of the sporogenous cell. At maturity the spore wall is formed and the spore separates from the mother-cell connection. It is pushed



out of the cup by the development of the next conidium. It has been impossible to determine accurately all details in the complete process of conidial formation. On some old phialides there appeared to be an accumulation of fragmentary membranes inside the terminal cup as if a portion of the enveloping membrane had been left each time a conidium was extruded. In some of the isolates such fragments were not in evidence. The conidia are extruded continuously in a mucous-like substance until the cell contents of the phialide are exhausted. Conidia produced on the aerial hyphae are held in packets at the tip of the phialides by the mucous. Where sporulation is copious, the masses appear as glistening globules.

#### TAXONOMY

##### THE FORM-GENUS SPOROTRICHUM

A brief discussion of the form-genus *Sporotrichum* will make it clear why the apple-rot fungus which has been discussed can not be maintained as a member of it.

Link (4) created the form-genus *Sporotrichum* in 1809 and included thirteen species in it. *S. badium*, the only one figured and the first one described, was originally considered as the type for the genus. In 1816, Link (5) again treated the genus, adding *Asporotrichum* and *Dematium*. He divided the genus into two sub-genera, *Lysisporium* and *Alytosporium*. In 1818 Link (6) revised the genus again, separating *Alytosporium*, which had constituted one of the sub-genera of *Sporotrichum*, thus no longer recognizing sub-genera. *S. badium* had been attached to *Alytosporium* and was no longer regarded as the type species for *Sporotrichum*. His revised key was based upon color, and various colors including black were listed.

Link (7) described the genus in 1824 as follows: Hyphae branched, all septate, sporophores without appendages, one celled, not septate and not agglutinated in the thallus (hyphal mat or colony).

Saccardo (10) interpreted the genus in 1880 as follows: Light colored, not brown, hyphae branched repeatedly, not erect, hyphae of equal diameter; conidia acrogenous on tips of branches or on small teeth, ovoid or subglobose. He cited *Sporotrichum roseum* and *Sporotrichum virescens* as examples.

Engler and Prantl (2) describe the genus as follows: Hyphae richly branched, widely spreading and all appressed, conidia apical, at tips of branches or on short sterigmata, mostly single, egg-shaped or spherical. Saprophytes, more than 120 species, of which almost half are assigned to Central Europe. A large number of these are doubtful. They figured *S. roseum* and *S. geochroum*.

There are probably three outstanding reasons for the confusion surrounding this form-genus: (1) The original inclusion of dark or black-colored fungi; (2) lack of an adequate description, especially of the manner in which the conidia are formed; (3) the uncertainty over what is to be considered the proper type species and the shifting from one species to another in an attempt to establish a type.

This review of the genus *Sporotrichum* is sufficient to show that the apple-rotting fungus, which has been designated as *Sporotrichum malorum* Kidd & Beaumont, can be excluded from the genus upon such characteristics as dark color in the hyphae, poorly to moderately branched hyphae, and in the mode of conidial formation.

It is therefore evident from the preceding discussion of the physiological behavior and morphology of the several strains, including Ruehle's "*Sporotrichum carpogenum*," that but one variable species is concerned and that it may properly be designated and given an amended description as follows:

PHIALOPHORA MALORUM (Kidd & Beaum.) McColloch, Phytopath. 32: 1094. 1942.

*Sporotrichum malorum* Kidd & Beaum., Trans. Brit. Myc. Soc. 10: 111. 1924.

*Sporotrichum carpogenum* Ruehle, Phytopath. 21: 1144-45. 1931.

Hyphae first hyaline, then fuscous to brown, septate, 1-4  $\mu$  in diameter, which show a tendency to adhere in rope-like strands, moderately branched, resting hyphae sometimes becoming moniliform; terminal and intercalary chlamydospores; conidiophores composed of specialized sporogenous cells, typically vase-shaped, 5-10.8  $\mu$  long, arising laterally, terminally or in clusters from the hyphae; conidia hyaline to fuscous, sub-globose to elliptical,

unicellular,  $4.2-7.8 \times 1.4-3.6 \mu$ , formed through a cup-like apex by a proliferation of the sporogenous cells, separated from the cells at maturity and held in a mucous mass.

Distribution: In surface soil and on cankerous apple wood in Virginia. Causing decay of apples in the United States and Great Britain.

#### ACKNOWLEDGMENTS

The author expresses thanks to Dr. Charles Thom for assistance in the identification of the fungus; to Miss Edith Cash and Dr. D. H. Rose for translations in connection with the literature reviewed; and to Mr. John A. Stevenson for many helpful suggestions during the preparation of the manuscript.

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## A NEW GENUS OF SMUTS

M. J. THIRUMALACHAR

(WITH 11 FIGURES)

*Heptapleurum venulosum* Seem. is a glabrous tree common in the mixed forests of Mysore. It bears in season small orange colored fruits which give it a very characteristic and attractive appearance and the tree is often grown therefore in ornamental gardens. One such tree growing in Lalbagh at Bangalore was found to be heavily infected by a smut. The smut is principally fructicolous (FIG. 2) but it also attacks the stems, the petioles and the leaves. In the attacked fruit, the embryo and the endosperm get replaced by a pulverulent mass of spores which are held together by the dried pericarp. Partially infected fruits are also common.

On the stems the smut is usually confined to the tips where the apical meristem gets displaced by the sorus which at first is sub-epidermal (FIG. 1). On the petiole, especially at the point of insertion of the leaflets, the smut forms black, wart-like (FIG. 3) sori. The sori on the leaves resemble the telia of *Nyssopsora Thwaitesii* (Berk. & Br.) Sydow, which is also common on this host.

For the study of the development of the sori and the spores, the best material proved to be the leaves and the pericarp of the fruits. These were fixed in Allen's modification of Bouin's fluid and also in Navashin's fluid as modified by Karpechenko. Embedded material was cut 6 to 10  $\mu$  thick and stained with Haidenhan's iron-alum haematoxylin or Newton's gentian violet.

The sori first appear in the intercellular spaces and gradually widen by the distension of the host cells. In a mature sorus (FIG. 10) two types of spores have been noted: (1) small two-celled oblong-ovate spores with rich cell contents and deep chocolate brown color, (2) large one-celled spores which are hyaline or pale yellow with degenerated cell contents and hence presenting a vacuolate appearance. The spores of the first category remain,

in many cases, one-celled due to lack of formation of the septa but they can easily be distinguished from the second category of spores described above. These latter are very much larger in size and their hyaline or pale yellow color distinguishes them from the mesospore-like spores that are also one-celled. The sori are thus heterosporous, a feature not so far recorded in the Ustilaginales.

Prior to the formation of spores the mycelium in the intercellular spaces becomes closely septate (FIG. 6) and the hyphal cells which are binucleate get gradually rounded (FIGS. 4 and 5). The sorus at this stage resembles the sorus of *Entyloma* but as development proceeds some of the cells become slightly ovate and richer in cell contents. A thick epispore then develops and a septum is formed (FIG. 7). The mature spores are deep chocolate brown with a minutely but deeply pitted wall which gives their edges a serrate appearance. Due to the lack of formation of septa these spores sometimes become one-celled, though in other respects they are identical with the two-celled spores (FIG. 8). Other cells in the meanwhile greatly enlarge in size, do not form a septum or develop any color. The cell contents of some of them degenerate, finally becoming vacuolate (FIG. 9).

The spores were germinated only with difficulty in plain agar in petri dishes. Germination was very capricious and took place after a lapse of much time. Germ tubes were put forth by the two-celled spores as well as by the one-celled pale yellow spores and the deeply chocolate brown spores (FIG. 11), but the hyaline vacuolate spores failed to germinate. Probably they are to be considered as sterile cells. Germination is by the formation of a septate promycelium on which sporidia are formed rather infrequently, both laterally and terminally. This mode of germination conforms to the type characteristic of the Ustilaginaceae. A peculiar feature noted in the germination of the spores of this smut, which has not been reported in any other genus of the order Ustilaginales, is the formation of a constrictor cell between the cells of the promycelium. This cell apparently helps to sever the promycelial cells easily and the separated promycelial cells probably assume the role of sporidia. The sporidia are globose, thin-walled and hyaline.

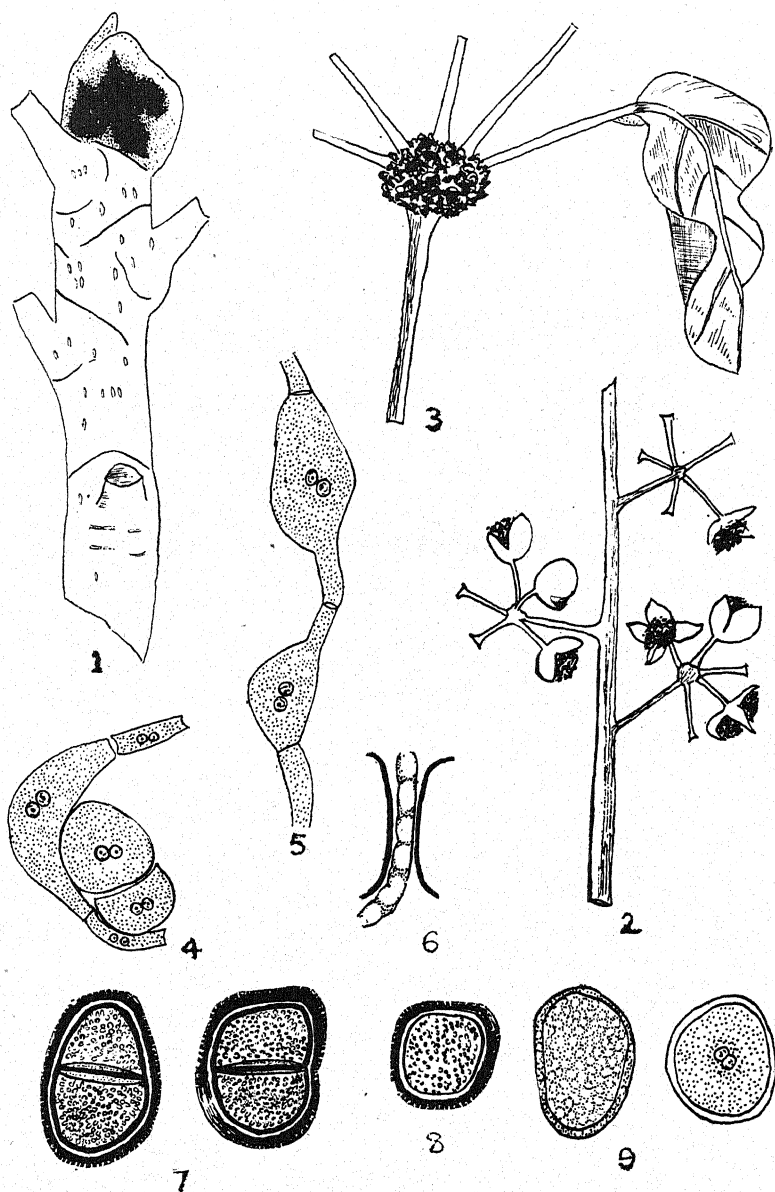


FIG. 1. Infection of twig,  $\frac{3}{4}$  nat. size; 2, infected fruits, nat. size; 3, infected petioles,  $\frac{3}{4}$  nat. size; 4 and 5, developmental stages of spores,  $\times 1800$ ; 6, septate hypha,  $\times 1800$ ; 7, mature 2-celled spores,  $\times 1800$ ; 8, 1-celled mesospore-like spore,  $\times 1800$ ; 9, hyaline 1-celled spores,  $\times 1800$ .

Two-celled spores, as distinct from spore-balls, are present in *Schizonella*, *Mycosyrinx* and *Schroeteria*. Species belonging to the genus *Schizonella* attack species of the genera *Carex* and *Elymus* and form their sori on the leaves. The spores which are two-celled are roughly dumbel-shaped but the two cells are easily detachable. In *Mycosyrinx* which attacks species of *Cissus* and *Vitis* and which forms its sori in the peduncles, the sori are enclosed in a double peridium and the two cells of the spores are attached by an isthmus-like structure but they easily get detached. In the genus *Schroeteria* which has been doubtfully placed in this Order, both two- and three-celled spores occur but on germination they form a long septate germ tube at the apex of which chains of conidia are formed. Neither Dietel (1928) nor Clements and Shear (1931) place it among the smuts though doubtfully placed in the Tilletiaceae by Lindau (1914) and Liro (1938).

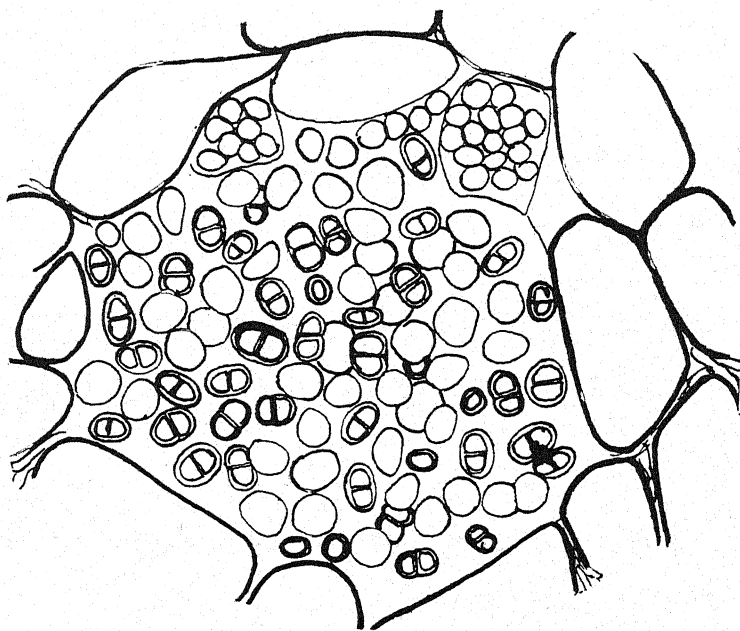
The unusual features which the smut on *Heptapleurum venulosum* possesses, and which are not found in any other genus of the Ustilaginales, entitle it to a place in a new genus to which the following name, for Dr. B. B. Mundkur, is given. These features are heterosporous sori, constrictor cells between the promycelial cells, viable one- and two-celled spores.

### **Mundkurella** gen. nov.

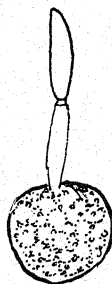
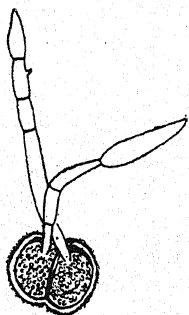
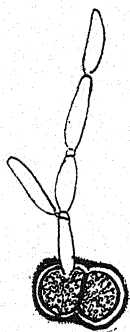
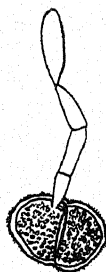
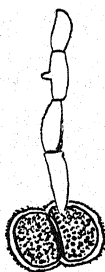
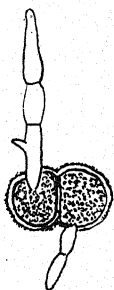
Sori in fructibus, caulibus, petiolis, atque foliis, heterospori, duplici sporarum genere praediti: (1) sporis unicellularibus, quarum quaedam copiosa inclusione atque lateritio-brunnea colore ditatae, quaedam vero pallide flavidae vel hyalinae sunt; (2) sporis bicellularibus, copiosa inclusione atque lateritio-brunneo colore praeditis. Germinatio per septatum promycelium; cellulae constringentes inter promycelii cellulas inveniuntur; plurimae sporae unicellulares vel pallide flavae, ut plurimum steriles.

Species typica: *Mundkurella Heptapleuri* Thirumalachar, *Heptapleuri venulosi* parasitica.

Sori in fruits, stems, petioles and leaves, heterosporous with two kinds of spores: (1) one-celled spores some of which with rich cell contents and chocolate brown colour and others pale yellow or hyaline; (2) two-celled spores with rich cell contents and chocolate brown colour. Germination by formation of septate



10



11



promycelium; constrictor cells between cells of the promycelium present; large number of one-celled hyaline or pale yellow spores, as a rule, sterile.

Type species: *Mundkurella Heptapleuri* Thirumalachar on *Heptapleurum venulosum* Seem.

***Mundkurella Heptapleuri* sp. nov.**

Sori heterospori, in fructibus, caulibus, petiolis et foliis; in fructibus endospermum atque embryo omino, raro partim tantum, destruuntur, sola testa intacta atque sporis pericarpio inclusis remanentibus. In caulibus sori subepidermales, omino evertentes meristematicas cellulas ex apice, earumque locum occupantes; in petiolis atque foliis nigras verrucas efformantes. Sporae duplicis generis; unicellulares subglobosae vel ovatae penitus lateritio-brunneae, flavidae vel hyalinae, sporae lateritio-brunneae 8.5–13.5  $\mu$  diam., sporae hyalinae magnitudinis 12–29  $\mu$  diam.; sporae bicellulares penitus lateritio-brunneae, inclusionibus copiosis atque granularibus, ovato-oblongae, 13.7–22  $\times$  10.3–13.5  $\mu$ ; episporium crassum, profunde atque minute excavatum, margine apparenter serrato. Germinatio per septatum promycelium, quod sporidia lateralia atque terminalia efformat; promycelium apparentiae insolitae, et ornatum cellulis constringentibus inter cellulas promyceliales; singulae bicellulares sporae et circiter 30 ex unicellularibus sporis viabilis; ceterae manifeste steriles.

Typus lectus a. cl. M. J. Thirumalachar super *Heptapleurum venulosum* Seem. 15–8–1942, Lal-Bagh, Bangalore, Indiae Or.

Sori heterosporous, in fruits, petioles, stems and leaves; in fruits endosperm and embryo completely and rarely partially destroyed, with only testa remaining intact and spores held together by the pericarp; in stems sori subepidermal, completely replacing the meristematic tissues at the apex; in petioles and leaves sori forming black warts. Spores of two kinds: one-celled spores subglobose or oval, chocolate brown, pale yellow or hyaline, chocolate brown spores measuring 8.5 to 13.5  $\mu$  and hyaline spores 12–29  $\mu$  in diameter; two-celled spores deep chocolate brown with rich granular contents, ovate-oblong, 13.7–22  $\times$  10.3–13.5  $\mu$ ; episporium thick, deeply and minutely pitted giving the edge a serrate appearance. Germination by the formation of a septate promycelium forming terminal and lateral sporidia; promycelium of unusual shape and provided with constrictor cells between the promycelial cells; all two-celled spores and about 30 per cent of one-celled spores viable, the rest manifestly sterile.

Hab. on *Heptapleurum venulosum* Seem. at Lal-Bagh, Bangalore, Coll. M. J. Thirumalachar, 15–8–1942 (Type); Coll. B. G. L. Swamy, 10–8–1942. Type deposited in the *Herb. Crypt. Ind. Orient.* New Delhi.

The writer wishes to express his gratitude to Dr. B. B. Mundkur, Imperial Agricultural Research Institute, New Delhi, for examining the smut material and for confirming the conclusions arrived at above, and to Dr. L. N. Rao, Professor of Botany, University of Mysore, for the help and encouragement given by him. Rev. Father H. Santapau, S.J., Ph.D., Professor of Botany, St. Xavier's College, Bombay, kindly rendered the diagnosis of the new genus and the species in to latin.

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## CONTRIBUTION TO THE EPIDEMIOLOGY OF TINEA CAPITIS. III. SOME DIAGNOSTIC PROBLEMS IN TINEA CAPITIS

TIBOR BENEDEK<sup>1</sup>

In two previous publications (1) a study of tinea capitis in a dispensary<sup>2</sup> was presented and (2) the epidemiology of this fungous infection as a public health problem in family and school<sup>3</sup> was investigated.

How timely these investigations were, suffice to point at the severe outbreak of tinea capitis in the Eastern States at the present time. The daily press carries alarming reports of the spread of tinea capitis on an epidemic scale among school children in Pittsburgh, Pa., Philadelphia, Pa., and New York, N. Y., as far as it came to my knowledge.

The imminent danger of the spread of tinea capitis on an epidemic scale as it was experienced during and after the first World War in Central and Eastern Europe presented itself in this country much earlier than it could be expected. I underscored the possibility of an epidemic, even pandemic outbreak of tinea infection since the current conditions in this country present all the requisites for such an occurrence.

Despite the great efforts for the improvement of diagnostic procedures there are still some problems which need clarification. In view of the present emergency I propose to present the standard procedure of investigations applied in every case of tinea capitis in our laboratory. By passing as the necessity may arise controversial problems will be discussed. Standard procedure of investigations followed the subsequent scheme:

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<sup>2</sup> Benedek, T. & Felsher, I. M. Epidemiology of tinea capitis. I. A study of tinea capitis in a dispensary. *Arch. Dermat. & Syph.* **49**: 120-123. 1944.

<sup>3</sup> Benedek, T. Epidemiology of tinea capitis. II. Tinea capitis as a public health problem in family and school. *Urol. & Cutan. Rev.* **47** (7): 416-432. 1943.

1. Clinical examination.
2. Examination of the scalp and face in Woodlight (fluorescence).
3. Demonstration of fungi on direct microscopic examination.
4. Culture of fungi from hairs and scales.
5. Identification of the growth with determination of the species.

#### 1. THE CLINICAL EXAMINATION: THE CARRIER PROBLEM

The first step to establish definitely the clinical diagnosis of *any* tinea capitis leads us to a problem of paramount importance, unknown in the past, very little discussed in the whole literature.

This problem is the *existence of carriers*. A "carrier" is a person who, without symptoms of a communicable disease, harbors and disseminates the specific micro-organisms. Carriers of fungal organisms in tineas cannot be detected by the most thorough clinical inspection. They do not reveal any clinical signs or symptoms, they simply present normal healthy scalps.

In order to detect carriers we always need some special tool to expose them. In typhoid carriers, for instance, this tool is the bacteriological method. Without proper bacteriological examination their existence cannot be detected and the carrier is a permanent danger of infection for the immediate surroundings and even for the larger community.

We face, *mutatis mutandis*, a similar problem dealing with tinea capitis. Between typhoid carriers and tineal carriers, however, there is a great difference. The primary infection in typhoid never goes unnoticed. It is promptly revealed by rather stormy clinical signs and symptoms. In tinea capitis, on the other hand, the primary infection is always insidious without signs and symptoms. Therefore, such a carrier is a potential source of infection from the moment as the fungus took foothold in the first hair follicle. Such a carrier potentially might spread the infection for weeks and months before the first sign of an infection can be detected clinically on his own scalp.

Due to these differences, the only tool which is absolutely reliable in the earliest detection and elimination of these tineal

carriers is not the microscope or the cultural method, *but the fluorescence phenomenon of the Woodlight*.

The importance of the Woodlight in the earliest detection of carriers, in the control of progress of our therapeutical measures, and in the determination of a final cure in tinea capitis must eventually be understood by all those dealing with this condition. Unfortunately, some of the largest American texts on Dermatology do not even mention the Woodlight and its paramount significance in the fight against tineas of the scalp. Some deal with this problem in an entirely insufficient manner. This is all the more surprising because R. W. Wood, an American physicist of world renown, gave this important tool to dermatology as one of the foremost single diagnostic tools almost a quarter of a century ago. The significance of the Woodlight as a diagnostic tool in tinea capitis is only comparable with that of darkfield microscopy in syphilis. Benedek gave recently a graphic demonstration of the importance of Woodlight in a publication on luminography (1).

To my knowledge, Davidson, Gregory and Birt (1934) (2) were the first who clearly recognized the carrier problem in tinea capitis. They examined 170 patients and contacts for ringworm of the scalp. On clinical examination, 31 out of 170 (18.2 per cent) were positive. All gave the positive test in Woodlight. However, among the 139 clinically negative cases seven (5 per cent) revealed positive fluorescence. They promptly concluded that the findings of fluorescent hairs on seven patients who were clinically passed as negative is the outstanding feature of this examination. They added furthermore that observation of kitten-carriers (3) throws new light on the epidemiology of ringworm of the scalp and *postulated* the possibility of human carriers of the disease.<sup>4</sup>

## 2. EXAMINATION OF THE SCALP AND FACE IN WOODLIGHT

The "clinical examination" played only a secondary role in the procedure to establish or to exclude the diagnosis of tinea of the scalp. Clinical inspection was, however, always the first step to

<sup>4</sup> Surprisingly even the latest publications (Lewis and Hopper (8), Livingston and Pillsbury (16)) do not deal with this problem.

start with, even though for nothing more than to be even more impressed by the revelation of the extent of fungus infection of the scalp and to bring home to our students in the class room and to the parents of our little patients, the efficiency and absolute necessity of the inspection of the scalp in Woodlight. The fluorescence usually revealed many scattered little tufts of hairs or even many isolated single hairs all over the scalp beside and beyond the clinically recognizable one or more smaller or larger foci.

I always insisted on the presence of the parents at the inspection of the scalps of our little patients in Woodlight. This served primarily not the purpose to keep them quiet or without fear in a strange and completely dark room. Our intention was to impress the parents, to win their collaboration and to induce them in that way to bring the whole family (not infrequently, we have had families with 5 to 9 children) for examination. We did not fail in any case.

From the very start of these investigations efforts were not restricted to the exclusive management of the individual case as dispensaries usually do, or at least did in the past. The survey was undertaken from the beginning from a broad, epidemiological point of view. The single case was only the lead, the clue to be followed in order to trace down the individual case to the source of infection; to establish the carriers in the family and to carry on the search for possible farther spread of the infecting agent into large communities like schools, kindergartens, asylums, etc.

Both in the dispensary cases and in a special investigation carried out in one whole public school with nearly 3,500 pupils (4, 5) the large percentage of carriers in the families and in the school room, was a great surprise. The number of carriers was 25 per cent in the dispensary material and 53 per cent in the school examined. These figures reveal the absolute necessity and paramount efficacy of the inspection of the scalp in Woodlight.

Just recently Cleveland (32) made a similar statement that as time passed he has been struck with increasing force by the observation that a large proportion of cases which have presented no clinical signs whatever, have been found nevertheless to be "Woodlight positive."

Concerning the problem of carriers I may give here one most illustrative case. A well developed negro girl, aged 17, came one day to the dispensary on account of a pityriasis versicolor.<sup>5</sup> After demonstration of the extent of this saprophytia on the body in Woodlight, I proceeded to show how normal black hairs fluoresce is a dusty grayish color. As the Woodlight fell on the luxuriant black hairs of the patient, beside the dusty-grayish fluorescence of the normal hair and beside the bluish-purplish color of the grease she had in some part of her hairs, she revealed *one single hair* in the central part of the hair glowing in a beautiful emerald-green color. It was unmistakably an infected hair. This single hair was epilated by hand under Woodlight. It was invaded by the fungus up to two cm. above the hair follicle. A portion of this hair served for microscopical examination, revealing the presence of microsporum. The larger portion was used for culture. It yielded a pure culture of *M. Audouini*. She had infected siblings at home and she became a carrier despite her age and overripe development.

Microsporum hair fluoresces in Woodlight with a beautiful, saturated copper-green or emerald-green color. Anthropophilic and zoophilic species give the same fluorescence in infected hairs. They thus cannot be told apart by the physical means, just as they cannot be separated in foretelling the species by microscopical examination. In this respect only the culture decides.

Since there are still some controversial views about the value and efficiency of Woodlight as a diagnostic tool in tinea capitis in the literature, a few critical remarks have to be added.

First of all, no difficulty was experienced to detect carriers in Woodlight even though the hair (like in many negro girls and boys) was richly greased. The white-bluish-purplish color of the

<sup>5</sup> We usually demonstrate this saprophytia to our students under Woodlight, because we want to call their attention to two facts, that (1) many patches of pityriasis versicolor can be seen scattered all over the body, often on neck, face, forehead, in areas which cannot be seen or detected at the closest inspection at the best daylight; and (2) to give the simple convincing reason of the up to date highly mysterious recurrences of this in itself harmless infection. In pityriasis versicolor like in tinea capitis we treated in the past only the clinically conspicuous, visible patches and let enormous numbers of parasites untouched, therefore the prompt recurrence.

plain grease contrasted even more with the emerald-green color of the microsporum infected hair.

Berde (6) called attention to the fact that sometimes cases of tinea microsporina and favosa, though clinically and mycologically proved beyond doubt as such, did not reveal either the usually intensive or characteristic fluorescence. He made this observation in three sisters infected with microsporum. Two of them revealed the usual sparkling fluorescence, the third was, however, negative. He attempted to find the cause of this peculiarity not in the species of the infecting agent, but in some "constitutional deviation" of the scalp from the normal or in the influence of some contaminant or in applied therapeutical means. Furthermore, this author assumed that desquamation of different (not fungal) origin, diverse chemical agents brought to the hairs incidentally or intentionally may elicit the same fluorescence as microsporum, favus, etc. He disagreed with Cleveland (7) who considered Woodlight as a tool of paramount importance in the detection of ringworm of the scalp.

I feel I have the right to take the stand in this controversial matter. I feel I can insist upon the correctness of these observations and the conclusions based upon and derived from them. I have observed a series of over 4,000 individual scalps; a large enough sequence, if not the largest single series ever observed, to have the proper safety margin of the laws of big numbers.

I definitely disagree with the statement of Berde that desquamation of different (not fungal) origin on the scalp may elicit the same or similar fluorescence as microsporum, favus or endothrix trichophyton. The only desquamative process that may raise some doubt or confusion at *clinical inspection* is the excessive form of *pityriasis capitis* or a mild *psoriasis*. We had several children under observation with these conditions in which clinically one could not exclude the possibility of a tinea capitis. In every case, one inspection under Woodlight positively ruled out the presence of any tinea. Microscopical and cultural controls always substantiated the correctness of the inspection, and the absence of any fungi. Seborrheic or psoriaticiform scaling of the scalp reveals a chalky-white fluorescence with hairs not fluorescing at all. There is no possibility for confusion of the emerald-green color of



a microsporum hair with the chalky-white color of seborrheic scaling.

Among the *chemicals* plain grease or oil (not medicated) having an explicit bluish-purplish color in Woodlight does not interfere with any fungal fluorescence.

Some chemical agents, however, may extinguish the fluorescence entirely. Salves containing salicylic acid may cover up the emerald-green color of microsporum completely by their own bluish-white fluorescence. This fact, however, cannot detract anything from the usefulness of the Woodlight as a diagnostic tool. If the salve was applied before, it was first removed by soap and water. Afterwards one never failed to see how far the infection is under control.

Rubbing off with benzine or alcohol the conspicuously infected areas of the scalp one could ascertain that these chemical agents do not influence the fluorescence in any way. Tincture of iodine, however, extinguishes the most intensive fluorescence momentarily.

Eventually I have to discuss a remark of Berde that sometimes cases of tinea microsporina and favosa did not reveal either the usually intensive or characteristic fluorescence. He assumed a "constitutional deviation" of such an infected scalp. Berde missed here a very important observation.

As to the plain fact it is true that sometimes in exactly the most severe cases of tinea microsporina the fluorescence is unusually dim. An inexperienced observer could definitely judge it as negative. Such extensive cases covering practically the whole scalp were seen by me in a few instances where I made a similar observation as Berde. These cases, however, do not constitute any puzzle or any kind of difficulty for clinical diagnosis. I was certainly puzzled observing these extensive infected areas in which here and there one or two single hairs gave the perfect emerald-green fluorescence, but otherwise the whole infected scalp was dimmed, almost blacked out.

I found the definite physical reason of this dimming or blacking out of fluorescence in tinea microsporina. I emphasize that I came across this peculiarity only in extensive cases which, of course, lasted one to two years, in one case over four years. I

found the solution of this interesting problem at the microscopical examination of a very great number of hairs and hairstumps from different parts of these scalps. It was found that hairs and hairstumps from dimmed or blacked out areas *do not possess any spore sheaths around the hair shaft*. In comparison the few scattered single hairs fluorescing in perfect emerald-green color revealed the existence of an intact spore sheath. Cultures from epilated hairs under Woodlight gave from both kinds of hairs exactly the same culture of microsporum.

*The lack of the spore sheaths causes the dim fluorescence or its blackout and not a "constitutional difference" in the scalp of the infected individuals.*

In cases of tinea trichophytina (endothrix) and tinea favosa Woodlight served a similar useful purpose in detection of infected single hairs or tufts of hairs outside the clinically anyway conspicuous areas. Endothrix trichophyton fluoresces on the scalp as a fine pale blue hue, favus hairs reveals a beautiful canary-yellow color. If one would have needed to be convinced of the usefulness of the inspection of the scalp in Woodlight two favus cases in the series would have sufficed.

I saw one boy, age 13, and a girl, age 11, in whom favus of the scalp persisted for 11 and 8 years respectively.<sup>6</sup> They have had ever since a "proper" medical care and their favus could not be eradicated. The Woodlight solved this problem. Beside the clinically visible foci there were numerous infected hairs, single or in small tufts, scattered over the scalp, far away from the clinically visible lesions. These hairs could be seen as infected ones only under Woodlight and not otherwise. That is the reason for the endless duration of a favus infection of the scalp because as in these cases only the visible areas were treated and not all the infected hairs.<sup>7</sup> I gave a similar reason for the continuous recurrence of pityriasis versicolor on the glabrous skin.

I observed three cases with large boggy kerions caused by *Achorion gypseum*. Beside the kerion, a few scattered hairs gave a dim pale bluish fluorescence.

<sup>6</sup> I thankfully acknowledge the referral of these two cases for mycological examination by our staff member, Dr. S. J. Zakon.

<sup>7</sup> Even after total epilation only the inspection of the scalp under Woodlight can reveal whether the therapeutical effort was successful or failed.

### 3. DEMONSTRATION OF FUNGI ON DIRECT MICROSCOPIC EXAMINATION

After clinical inspection and careful observation of the scalp under Woodlight the diagnosis was always verified by direct microscopical examination of the hairs. An absolute parallelism was found in microsporum, favus, endothrix trichophyton hairs between the fluorescence in Woodlight and the presence of fungal elements under the microscope. On the other hand, microscopically negative hairs do not fluoresce at all. Therefore the final decision for the discharge of the patients was made not by means of microscopical examination but by the fluorescence test in Woodlight.

I absolutely discarded the use of potassium hydroxide (KOH) for the microscopical examination of hairs and scales. Instead I use one of the following solutions:

#### (1) Chlorallactophenol:

Rx chloral hydrate cryst.....	20.0
acid. carbol. cryst.....	10.0
acid. lactic. pp.....	10.0

S. mix and dissolve on waterbath.

#### (2) Salicylated chlorallactophenol:

Rx chloral hydrate cryst.....	40.0
acid. carbol. pp.....	40.0
acid. lactic. pp.....	20.0
sod. salicylate.....	10.0

S. mix and dissolve on waterbath.

If staining of the specimen is desirable (usually not for the routine examination) *the liquid of amman* with cotton blue (C4B Poirier) can be recommended:

Rx acid. carbol. cryst. pp.....	10.0
acid. lactic. pp.....	10.0
glycerin.....	20.0
acqua dest.....	10.0
cotton blue.....	0.05

S. mix and dissolve the first four ingredients in the order given on waterbath, then add cotton blue.

I cannot agree with Lewis and Hopper (8) who gave also their special attention to this matter that "For ordinary routine use we

have not found anything better than a 10 per cent solution of potassium or sodium hydroxide." <sup>8</sup>

Using even a 10 per cent KOH or NaOH (let alone a solution of 40 per cent!) the solution quickly absorbs CO<sub>2</sub> from the air at the opening of the container whatever it may be. The result is the formation of potassium or sodium carbonate (K<sub>2</sub>CO<sub>3</sub> or Na<sub>2</sub>CO<sub>3</sub>) as a crystalline sediment, reducing at the same time the effective hydroxide almost to nil. Such a solution, I need not emphasize, is absolutely useless. This is the chemical side of the problem.

The mycological side, however, is even more important. Using KOH for clearing of the material (hairs or scale) even the natural fat of the hair, let alone the grease often applied to them, is most disturbing. If the cold process is used for clearing, the crystallization of the hydroxide or (mostly) the presence of carbonate crystals mingled with fat is highly disturbing. If the hydroxide preparation is even gently heated the saponification of the grease can make the observation, particularly for less experienced examiners, very difficult. Last but not least, if such a preparation is heated a little bit more energetically the whole structure of the hair—is entirely destroyed, the hair appearing like "exploded."

Removing the fat previously by acetone, alcohol or ether is tedious, time consuming and using a chlorallactophenol formula, entirely superfluous job. Furthermore hydroxide preparation cannot be stained and only with difficulty conserved. All these difficulties are met with and promptly overcome using one of the above formulas.

The advantages (I never found any disadvantages) of chlorallactophenol formulas are the following: (1) it is a cold process, no warming or heating is necessary; therefore the structure of fungal elements and their natural relation to the host cells are perfectly preserved; (2) fat adherent to hairs or scales does not disturb the picture because there is no saponification; (3) animal tissue (hair, scale, pus cells) becomes absolutely transparent leaving the vegetable elements (spores, mycelium, etc.) in full conspicuity; (4) there is no influence of CO<sub>2</sub> from the air; (5) the preparation

<sup>8</sup> Current dermatological texts give usually the advice to use a 40 per cent KOH solution. Such advice can be traced to some ancient outmoded source of information and uncritical compilation.

as it is made without any further time consuming manipulation can be conserved by simply framing it by wax or resin. Formula 1 can be used for scales and lesser pigmented hairs; formula 2 is the best for heavily pigmented (negro) hairs; formula 3 can be used at any time if staining of a specimen is primarily desirable.

I referred to the repeated observation in long-standing cases of microsporum infection of the scalp that hairs do not show any spore sheath, nonetheless, the hair shaft is filled with mycelium. In these not so rare instances the question arises whether the observer is dealing with an endothrix (*Trichophyton*) infection or not. There is a sure objective sign to differentiate the (in reality) microsporum hair from a supposedly endothrix hair. This sign is given in the state of the hair cuticle. In a typical endothrix infection, the cuticula of the hair shaft is absolutely smooth, intact. In the case of a microsporum hair without spore sheath the cuticula is roughened up, torn up here and there and its continuity is in many places disturbed, of course, without seeing any spores outside and along the hair shaft.

I made another interesting observation in long-standing cases of microsporum infection. I have had several boys under observation (white boys, with blond hairs) who showed one from 3 to 5 cm. large round patch of microsporum infection on the occiput. Due to circumstances beyond our control these boys disappeared after the first few consultations for many months from observation. When eventually seen again 10-12 months after the first consultation I surprisingly made the observation that (1) the infected patch remained isolated; no spreading took place; (2) the hairs were invaded 2-3 cm. long with mycelium showing up with whitish-bluish fluorescence, and not revealing microscopically any spore sheath. The culture, however, carried out with great care, revealed that these hairs were invaded by *M. Audouini*.

It seems to me that in long standing infections there is some balance (immunity of the scalp?) between fungus and the host developing and very little or no tendency of spreading; further that the fungus (*M. Audouini*) changes somewhat its relationship to the hair, remaining entirely "endothrix." These hairs are usually long as healthy hairs (I made the similar observation in

both cases of favus), they do not break off, they do not reveal cross breakage of the shaft under the microscope along their whole length and they can be discovered as infected, exclusively under Woodlight.

*These cases are the worst carriers.* Clinically they show not the least change or deviation from normal hairs, they spread the infection nevertheless, judged by the intensive growth of the fungus from these peculiar hairs in the culture.

#### 4. CULTURE OF FUNGI FROM HAIRS AND SCALES FROM STANDPOINT OF EPIDEMIOLOGY

As is well known, the differentiation of so-called "species" of dermatophytons, *Microsporum*, *Trichophyton*, *Epidermophyton* was fundamentally based in Sabouraud's system, beside their relationship to the hair and epidermis and certain general microscopical features,—on their aspect and appearance in the giant culture. The basis of comparison was given by Sabouraud's famous "milieu d'épreuve," made up with raw French glucose and maltose and pepton Chassaing. It was always understood that these carbohydrates were chemically impure carrying with them qualitatively and quantitatively an entirely unknown amount of "accessory" material which possibly being vitamins in character, gave rise to luxuriant giant cultures. The peptone used was itself of an unknown and unsteady compound.

The luxuriant growth and the surface configuration (the most important differentiating characteristics for the giant culture in Sabouraud's system beside their color) could not be well reproduced in an identical way by any other combination of peptones and carbohydrates of German, French, Hungarian or American origin.

Medical mycologists all over the world willingly accepted Sabouraud's "milieu d'épreuve" as the international comparative nutrient medium, while botanical mycologists like Linder (9)<sup>9</sup>

<sup>9</sup> Linder (l.c.p. 455-456) said: "It is my firm conviction that the almost universal use of Sabouraud's agar has done more to confuse taxonomy than any single factor. Peptone or peptones and sugar in agar, as used in the past, are not only unbalanced and do not furnish all the elements necessary for the normal growth of the fungi, but when these substances are supplied, they are in too great concentration. Test-tubes do not furnish a normal habitat, but when to this is added unfavorable nutritional factors, there is little wonder that the organisms go wild and produce all sorts of mutation."

frowned upon it for many good reasons. It is, however, well known to those who had opportunity as the writer, to work with Sabouraud's "milieu d'épreuve" for many years and had the opportunity to compare in the long run giant cultures of the same species on different batches of the French carbohydrates and peptones, that even this milieu d'épreuve proved to be inconstant to a lesser or a greater degree in reproduction of the size, shape, configuration, color of the same species in the giant culture.

Up to the outbreak of the first World War French material was easily available all over the world. The war and subsequent difficulties in the international exchange of goods made in this respect a definite break, which chasm is deepened to an indefinite interruption. Sabouraud's "milieu d'épreuve" is past history.<sup>10</sup>

Yet from the standpoint of epidemiological research a comparative nutrient medium was obviously of paramount importance. Weidman and McMillan (1921) in the United States, G. Pollacci (1922) in Italy, O. Grütz (1923) in Germany, Goldschmidt (1924) in England tried to evolve a comparative nutrient medium from national resources to replace Sabouraud's original milieu d'épreuve but without stretch of imagination the giant cultures of the same dermatophyte could be hardly compared with the pictures published in Sabouraud's magnificent volume "Les Teignes," in 1910.<sup>11</sup>

Based on his milieu d'épreuve, Sabouraud established beside the type species in *Microsporum*, *Trichophyton*, a great number of "satellites" as valid species based mainly on slight differences of the giant culture in color, configuration of the surface, rate of growth, etc. These satellites are, however, no valid species in a botanical sense of the term. Following the path of Sabouraud, particularly in the twenties of the present century, the strange habit developed among medical mycologists to create unneces-

<sup>10</sup> What we currently understand under "Sabouraud's media," the Difco Sabouraud media, for instance, has nothing in common with the original French media of Sabouraud but the name. The American Difco media use chemically pure carbohydrates and peptones and there is no identity whatsoever of the same species on the original French and Difco Sabouraud mediums.

<sup>11</sup> Bruhns and Alexander (Allgemeine Mykologie und Biologie, Jadasohn's Handb. d. Haut- u. Geschlechtskr. Xi, 1928, J. Springer, Berlin) give many comparative pictures of dermatophytions on these different media.

sarily, without valid botanical differences, a great number of new species in the genus *Microsporum*.

Beside the valid type species of the genus *Microsporum*, *M. Audouini*, *M. lanosum*, *M. equinum* and the far Eastern *M. ferrugineum*, Bruhns and Alexander (10) list not less than 25 different "species" of *Microsporum*. This "differentiation," of course, has no botanical validity. The reason of this erroneous trend in creating new species can be easily found in the fact that Sabouraud and after him many medical mycologists did not take into account the great, sometimes, excessive *variability* and the *dissociation* within the valid species of the dermatophytos. Emmons (11) gave a graphic demonstration of these facts in the genus *Achorion* (1932). Benedek (12) demonstrated particularly the phenomenon of dissociation in the genus *Microsporum* (1938).

I have to specifically mention two "satellites" of the *M. Audouini* on the basis of my large experience, which caused much unnecessary discussion in Europe. Guéguen in 1911, W. Fischer in 1921 described a *Microsporum depauperatum*, Klehmet in 1919 and in 1921 again presented a *Microsporum pertenu* as new species of the genus *Microsporum* belonging to the anthropophilic (human) group of *M. Audouini*.

I saw not so rarely among the hundreds of cultures of *M. Audouini* similar strains which fairly well compared in their rate of growth, color, surface configuration with the *M. depauperatum* or *M. pertenu*. Through comparative microscopical examination, the attitude of these deviating strains on rice medium, their biological attitude on rice in the presence of the unilateral stimulating symbiont of *B. weidmaniensis* Benedek (13), left no doubt that these species are invalid. In the best case, they are to be considered as slight variants of an unstable species (*M. Audouini*). Bruhns and Alexander also considered *M. depauperatum* and *M. pertenu* nothing more but as slight variants of *M. Audouini*.

It is of great historical interest to refer here to the thorough study of Ch. J. White on "Ringworm as it exists in Boston," in 1899. This great pioneer and excellent observer called attention



at this tender age<sup>12</sup> of medical mycology that "there were four anomalous cultures isolated from specimens of *M. Audouini*." Yet, in recognizing the "variants," he did not create unnecessary new species. Ch. J. White's description of these four "anomalous cultures" deserves to be taken from oblivion, to show posterity the precise observation, evaluation and description of mycological phenomena by an early pioneer, which height was not reached by many later workers in this field.<sup>13</sup>

Based on our present knowledge and retaining in principle Sabouraud's system of the dermatophytos as the only adequate system for dermatologists, although botanically it may be objected, I recognize only one anthropophilic type of the genus *Microsporum*, the *M. Audouini*. Their satellites listed by Sabouraud, compiled by Bruhns and Alexander, have to be dropped entirely. It is commendable that Lewis and Hopper

<sup>12</sup> Sabouraud's study on dermatomycoses as a preliminary report was published in book form in 1894. (Sabouraud, R.: *Les Trichophyties Humaines*. Paris, Rueffs & Co., 1894.)

<sup>13</sup> "There were four anomalous cultures isolated from specimens of *M. Audouini*. The first plant was evidently closely allied to the usual type, for the growth consisted of the white aerial, fluffy hyphae, but the central tuft was displaced by an area perhaps 1.5 cm. in diameter, much denser and whiter than the surrounding growth, and the usual concentric circles and the radiating sulci were totally lacking."

"The second important variation exhibited a growth whose vitality seemed to be greatly diminished. The usual abundant growth of the hyphae occurred about the inoculated tissue and then all further life apparently ceased. This phenomena was observed in 3 cases—2 from the scalp and one from the neck."

"The third of the rare forms of culture was derived from the beard of a man of 45. The growth is composed fundamentally of very delicate radiating hyphae, laying in such a transparent layer that they produce no color, but assume that of the medium. Superimposed is a homogeneous, downy, white layer, which is not produced as quickly as that of the hyphae, but increases peripherally, leaving always a free margin of the colorless hyphae."

"The fourth anomaly was extremely interesting and one wonders if the microsporum causing this culture can be related to the Italian plants which produce the violet cultures described by Mibelli. This culture was derived from scales from the scalp of a child of four. The central portion consists of a rosette-like elevation so dark that one would hesitate to describe its color. Surrounding this central zone is a circle composed of delicate, radiating hyphae, of a red-violet tint, and outside of all a third belt of pale lavender. The growth is distinctly small and never attained a diameter of more than 1.5 cm." —(This latter variety, of course, definitely refers to *Tricophyton violaceum*.)

already carried out this logical simplification and dropped all "satellites" of *M. Audouini* as separate species.

As to the zoöphilic type of *Microsporum*, the second most frequent species in my material was the *M. lanosum* (Sabouraud, 1907). I recognize only this species as valid and I drop the *M. felineum* (C. Fox and Blaxall, 1896) as a separate species entirely. Jacobson (14) listed *M. felineum* only as a "satellite" of the *M. lanosum* in 1932, Lewis and Hopper (1939) dropped it even as such. Davidson and Gregory (3) followed Langeron and Milochevitch (Ann. Parasit. 8: 465-505, 1930) in joining *M. lanosum* Sab. 1907 with *M. felineum*.<sup>14</sup>

In my own experience I could not find any support for the purpose to carry on *M. felineum* either as a satellite or, let alone, as a species. As to the clinical picture they cause the same type of lesions. As to their microscopical morphology in the lesion, in the culture, as to their attitude on natural mediums (rice) except for some slight difference in the giant culture (varying from medium to medium) there are no valid differences between the two.

To keep up even in name the differentiation between *M. caninum* and *M. felineum* would seem to me all the more difficult and without any real factual basis, because one cannot prove the transmission of the infecting agents from the respective animals (dog, cat) to humans. Despite strenuous search and questioning, even inspecting the pets, dogs and cats, from respective households, clinically and under Woodlight, I could not connect in my material any case with *M. lanosum* or *M. felineum* to dogs or cats in the surroundings of our patients.

It is possible that zoöphilic species are originally bound to their animal hosts alone or mainly. Later in the course of cross infections between animals to humans and vice versa,<sup>15</sup> however, the zoöphilic species were carried on so persistently by human hosts

<sup>14</sup> Sabouraud himself wrote: "En fait, rien ne savait différencier mycologiquement le *Microsporum felineum* du *Microsporum lanosum*; l'examen microscopique de leurs cultures les montre indifférenciables entre elles." Les Teignes, p. 687. Paris, Masson & Co. 1910.

<sup>15</sup> Davidson and Gregory (3) reported a fine observation of cross infection between kitten and child and vice versa.

alone that there was no necessity for the pathogenic agent to return to the primary animal host.

This change in the host for the originally zoöphilic *M. lanosum* is proved also by the present material. *M. lanosum* caused, at least in the half of the cases related to it, torpid, non-inflammatory lesions on the scalp, indistinguishable from the anthropophilic *M. Audouini* infection. On the other hand, the evidence showed that half of the kerions was caused by *M. Audouini*, a fungus causing originally only torpid, non-inflammatory lesions on human scalps.

I have to call attention to this conspicuous change in the host relationship of zoöphilic and anthropophilic species, because the earlier accepted rule that anthropophilic species in humans cause only non-inflammatory, zoöphilic species, on the contrary, only inflammatory lesions, does not hold true at present any more.

In the genus *Trichophyton* the whole material revealed only one species, *T. crateriforme*, once, in two White siblings.

Morris Moore (15) stated in a discussion of the paper of Livingood and Pillsbury, in very general terms, that in the past several years, he found only two cases of tinea capitis among his material due to *M. Audouini*. The rest were due to *M. lanosum*. He found "a number of strains of this particular organism (*M. Audouini*) so closely related to *lanosum* that he doubts if it is possible to distinguish between the two."

This comment is rather peculiar. It is true that in a large material like that of Ch. J. White, mine, one will find a number of strains being peculiar, but they are under no circumstances "related to *lanosum*." To raise doubt, however, as M. Moore does about their being distinct species (*M. Audouini* and *M. lanosum*) would mean, without any positive evidence advanced, to carry confusion in well established knowledge. Moreover, Conant first showed conclusively that using polished rice medium any strains—peculiar or not—of *M. Audouini* can be distinguished from any strain of *M. lanosum*. Benedek (13) substantiated Conant's observation completely.

A further remark of M. Moore that tinea capitis in the Middle West region was found to be largely due to *M. lanosum*, does not hold true, either. Chicago is uncontestably in the center of the

Middle West. The present material reveals 79 per cent *M. Audouini*, and only 13.9 per cent *M. lanosum*. Epidemiological research must always be based on large material observed and collected through a longer period of time to enable us to make proper generalizations.

Livingood (16) pointed out in his closing remarks that they had "no difficulty" in distinguishing the species of fungi by the method outlined in their paper and it is well to emphasize again that the examination of the giant culture under Wood's light is an extremely valuable aid in identification."

I shall come back later to this last remark. Eventually, I have to make a few remarks concerning *Achorion gypseum* Bodin, 1907. I identified this fungus three times in my material. According to the statistics of Bruhns and Alexander (1928) this fungus is one of the rarer pathogenic agents. It was found in scattered single cases in France (Sabouraud, 1894, Bodin, 1907); in Italy (Porcelli, 1922, Mazzini, 1925, Truffi, 1913 and 1923); in Austria (Vienna) (Scherber, 1914, Stein, 1921, Tschirntsch, 1927); in Denmark (Rasch, 1922); in Germany (Bruhns and Alexander in Berlin, Werther in Dresden); in Hungary (Neuber, 1921).

As far as I could ascertain *Achorion gypseum* was found and reported in the United States previously only twice, once by Rockwood (17) in Boston, and another time by Emmons (11) in New York. This is, however, the first time that occurrence of *Achorion gypseum* is reported from Chicago.

The taxonomic position of this fungus is most peculiar. Sabouraud in 1894 (18) described it as a *Trichophyton* (*Trichophyton du chien*); Bodin, in 1907, (19) as an *Achorion*; Conant, in 1926, (20) as a *Microsporum*. Lewis and Hopper, in 1939, gave some short and incomplete accounts of this fungus making the terms: *Microsporum fulvum*, *Microsporum gypseum* and *Achorion gypseum* in an unmistakable effort of simplification of our nomenclature, synonymous (l.c.p. 284).<sup>16</sup> This is, however, an obvious error.

<sup>16</sup> Lewis and Hopper registered, in 1935-1938, in New York three times "*Microsporum fulvum*." Livingood and Pillsbury, in 1941, found "*Microsporum fulvum*" once in Philadelphia. They attached a footnote (l.c.p. 45) to *M. fulvum*: "Mycologic studies done in collaboration with the Laboratory of Dermatological Research, University of Pennsylvania." By implication,

The type species of *M. fulvum* (J. Uriburu, 1907) was established by Sabouraud in a specimen sent to him by Uriburu from Buenos Aires. Ballagi (21) found this fungus in 1916 in three cases in Hungary. Sabouraud, Ballagi emphatically pointed out that the microscopical characteristics of this fungus in the hair, in other words, the relationship between fungus and hair shaft is absolutely *identical with that of M. Audouini*. *M. fulvum* is *definitely a microsporum*.

On the other hand, considering the relationship between the fungal elements of *Achorion gypseum* and the hair, I found a surprising variation in this respect. In one case, it revealed the type characteristics of a *Trichophyton endothrix*; in the second instance it showed the type characteristics of a *Trichophyton ectothrix* and in the third case it was a typical endo-ectothrix. It represents one of the fastest growing species of the dermatophytes with a surabundance of organs of fructification, multilocular giant macroconidia (spindles), some aleurospores. A 72 hours old hanging drop culture shows already a surprisingly great number of these spindles.

The only valid species name of this fungus is therefore *Achorion gypseum* Bodin, 1907; it must not be confounded with another valid species, the *Microsporum fulvum*, and, of course, they are not identical and their names are not synonymous.

In Sabouraud's complicated system of dermatophytes the first basic principle is the relationship of the fungous elements to the hair. In this respect the *Achorion gypseum* is a *typical Trichophyton* as Sabouraud first classified it in 1894.<sup>17</sup> Whether it is

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I may assume that Fred D. Weidman identified this fungus as *M. fulvum*. Therefore, I accept this diagnosis, although Livingood and Pillsbury do not give either an illustration or description about the characteristics of this fungus in its relationship to the hair.

<sup>17</sup> It is interesting that Sabouraud changed his views in the following decades. But seemingly, except for his first case (1894), he had little or no opportunity at all to carry on a more thorough study of *Achorion gypseum* and its relationship to the hair. This fungus does not occur in Paris, or at least after its discovery by Sabouraud in Paris, in 1894, and after its rediscovery and final valid description by Bodin, 1907, it was never mentioned again in the French literature as far as I could ascertain.

Sabouraud, in 1936, writing the last time on this subject (R. Sabouraud: Les Microsporida, in Nouvelle Pratique Dermatologique, Masson & Co.,

an endothrix, an ectothrix or ecto-endothrix, the mycelium is straight, breaking up in rosary like *rectilinear* rows, as the case is in *Trichophyton*. No hair—I examined dozens of them in each of the three cases—ever revealed a spore sheath consisting of *spores of mosaic-like arrangement* which is distinctive and absolutely characteristic for the relationship between parasite and hair in the whole genus of *Microsporum* without exception.

The second of the basic principles, if available, is the relationship of the infecting fungus to the hair in experimental animals, most suitable in guinea pig. All the three strains of *Achorion gypseum* showed in guinea pig hair a typical, purely endothrix character and not a mosaic-like spore sheath, so characteristic for *M. lanosum* in guinea pig hair, for instance.

The only group of dermatophytes characterized by permanent or casual scutulum formation is the genus *Achorion*. Bodin first observed this scutulum formation by *Achorion gypseum* and therefore he put this fungus into the genus *Achorion*. The *Achorion Quinckeanum*, for instance, is placed in this genus for the same reason, the scutulum formation, although it has a typical *Trichophyton* fructification.

Conant (20)—and lately Sabouraud<sup>18</sup>—put *Achorion gypseum* as "*Microsporum*" *gypseum*, in the genus *Microsporum* on account of its surabundant production of spindles as organs of fructification. That is, however, no valid reason. Even though the genus *Microsporum* is mainly characterized by the production of macroconidia as the main organ of fructification, we meet with macroconidia in the genus *Epidermophyton* and even exceptionally in the genus *Trichophyton*.<sup>19</sup> Yet, nobody would try to put *Epidermophyton inguinale* in the genus *Microsporum* due to its characteristic organ of fructification, the macroconidia. The

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Paris, 1936, vol. 11: 125 pp.) made the following statement: (pl. 147, l.c.) "J'ajoute que l'*Achorion gypseum* de Bodin est mycologiquement pareil aux *Microsporums* animaux et de toute evidence doit, du point de vue botanique, être rangé à côté d'eux. La seule difference notable entre eux vient de ce fait que les fuseaux, en navettes, de ces parasites sont réunis on cymes de dix et douze fuseaux, à l'extrémité d'un même ramau aérien."

<sup>18</sup> See footnote page 31.

<sup>19</sup> For instance, in *T. purpureum*, *T. gypseum*, cf. A. E. Edgecombe: *Trichophyton purpureum* (Bang) and *Trichophyton gypseum* (Bodin). Arch. Dermat. & Syph. 46: 651-660. 1942.

determining factor for the latter group of fungi is their relationship to the stratum cornum, and as a negative characteristic that they never invade the hair shaft.

Eventually the cultural characteristics, the rate of growth, the early, rapid and abundant production of spindles, the flat giant culture with its fawn color, last, but not least, its accessive variability on artificial media (Emmons, l.c.) definitely separate this dermatophyton from the genus *Microsporum*.

Lewis and Hopper proved it conclusively (l.c.p. 250, fig. 51) by the illustration given for "*Microsporum fulvum*" that they had *Achorion gypseum* and not *Microsporum fulvum* in their hand. The same holds true for the case published by Moore and Conrad (22).<sup>20</sup>

#### 5. IDENTIFICATION OF THE GROWTH AND DETERMINATION OF THE SPECIES

For this purpose, I used (1) the observation of test-tube cultures (Difco Sabouraud glucose or maltose medium) directly on the microscope stage by means of Benedek's mycological stage clamps; (2) hanging drop cultures by using thin films of the same medium; (3) polished rice medium; (4) the fluorescence phenomenon of test-tube cultures and giant cultures.

(1) The direct observation of the development of the test-tube cultures under the microscope, made possible as a routine method by Benedek's mycological stage clamps, has great advantages, particularly in a mass investigation as the present one. The special technic of inoculation of agar slant mediums, the purpose, the necessity and advantages of this method for routine examination, for comparative study and for photomicrographic purposes were amply described in several publications by the writer. Here, I simply refer to them (23, 24, 25).

(2) As to the hanging drop cultures I have only to remark that I usually used thin films of Difco Sabouraud glucose or maltose

<sup>20</sup> Moore and Conrad illustrated an infected hair demonstrating "filaments and chains of spores." Moreover, they did not give any sufficient description of their own observation of the basic relationship between fungus and hair. Their only sentence (p. 613): "Microscopically the fungus on the infected hair may simulate microsporum of animal origin or at times *Achorion Schoenleini*" is strikingly contradicted and disproved by their illustration given.

mediums as "hanging drop" instead of glucose or maltose broth. I always reached the same goal, even better, and the thin solidifying film was easier to handle than the broth. However, I often added 0.1 per cent eosin or 0.01 per cent methyl blue to the bulk of the mediums which caused vital staining of the whole growth giving beautiful detailed pictures during the whole development of the fungus. For more detail on vital staining of fungi, I refer to the publication of Williams (26).

(3) In my technic, however, the polished rice medium played the most important role for identification for anthropophilic and zoöphilic strains of *Microsporum*. As a rule every freshly isolated strain of *Microsporum* went through rice medium in the process of identification in the laboratory because this method is at present the only sure way to exactly differentiate anthropophilic and zoöphilic strains in the genus *Microsporum*.

During the comparative study of the genus *Microsporum* Conant (20) found that *Microsporum Audouini*, in sharp distinction from *Microsporum lanosum*, does not vegetate on rice medium. A few years ago already, during a study of a newly discovered species of *Microsporum*, *M. Stilliansi* Benedek, 1938 (12), making comparative investigations with *M. Audouini* and several zoöphilic species of *Microsporum* on rice medium, Benedek readily substantiated the observation of Conant as to the difference of viability of human and animal species of *Microsporum* on rice.

The present large study gave ample opportunity to prove again and again the correctness of this observation.

The use of polished rice medium eliminates the difficulties in identification of strains of *Microsporum* and it is the solution of the problems M. Moore referred to.

(4) Due to a remark of Livingood and Pillsbury (l.c.p. 54) that "Fluorescent light examination of giant cultures proved an extremely useful adjunct to standard methods of identification of fungus species," I was extremely intrigued, to pay special attention also to this method which in the hand of this writer in previous unpublished experiments did not lead to any useful and conclusive results. I was, however, not only intrigued by Livingood and Pillsbury's remark, I was directly struck by the lack of evidence



and by the want of any necessary reference to the work done in this field by others in due support of their statement.

Summarily, to begin with, there is no support for Livingood and Pillsbury's statement in the whole world literature as far as I could ascertain by careful search.

Authors who paid their special attention to the fluorescence phenomenon of dermatophytos in giant cultures are Berde (6) Davidson and Gregory (27), Mallinckrodt-Haupt and Carrié (28).

A few short remarks on fluorescence of hyphomycetes in general in giant cultures can be found before these authors in literature. Danckwortt (29) stated that colonies of molds fluoresce pale purple. Margarot and Devèze (30) made the same statement on *Trichophyton*.

Berde made his investigations into the fluorescence phenomenon of giant cultures of dermatophytos by using four different agar mediums with maltose, glucose, honey and a pepton agar medium free from carbohydrates. The fungi grown on these media could be divided according to their fluorescence into three groups. (1) *Hemispora porcelli* and *Hemispora rugosa*, *Microsporum ferrugineum*, *Trichophyton plicatile*, *Achorion Schoenleini*, *Saccharomyces Binot* and *Saccharomyces San Felice*, *Actinomyces bovis*, *Actinomyces madurae*, and the pigment producing strains of *Sporotrichum* do NOT fluoresce at all; their colonies appear in Woodlight dark gray or black. (2) *Microsporum Audouini*; *Trichophyton cerebriforme*, *violaceum*, *niveum*, *fumatum*, *equinum*; *Epidermophyton inguinale*; *Achorion Quinckeanum*, *Achorion gallinae* reveal a pale purplish fluorescence, while (3) *Oidium albicans*, *Sporotrichums* producing no pigment, *Mycoderma cutaneum* and the giant colonies of some yeasts showed up in a striking white light.

Berde had already observed, however, that the chemical compounds of the nutrient mediums play a decisive role in some dermatophytos as to the fluorescence of their growth on these mediums. He found, for instance, that *T. cerebriforme* fluoresces brown, grown on mediums containing carbohydrates, while it shows up in purple color on a carbohydrate-free medium. *Trichophyton violaceum* fluoresces purple with, and black without, carbohydrate in the medium. *Achorion gallinae* fluoresces purple

on maltose agar, red on carbohydrate-free medium. *Trichophyton gypseum asteroides* revealed a quite peculiar fluorescence, entirely different from any other, revealing a pale blue color, which was, however, inconstant as to its appearance and its distribution.

Berde came to the conclusion based on his extensive experimental work that fluorescence as an adjunct means for identification of dermatophytos can be used only for *T. gypseum asteroides* under exclusion of all other fungi.

Mallinckrodt-Haupt and Carrié have not been successful by examining 200 giant cultures of dermatophytos grown on Sabouraud agar mediums to establish a fluorescence in Woodlight corresponding to the clinical findings. Also numerous investigations on liquid Sabouraud mediums did not lead to any positive results. *By no means was it possible*, they concluded, either on Sabouraud's solid mediums or on liquid mediums with addition of different ingredients *to elicit a definitely proven fluorescence in a fungal culture*.

Davidson and Gregory noted that the green fluorescence of microsporum infected hairs is not observed macroscopically in cultures of the organisms when grown on Sabouraud's medium. The cultures frequently appear in a violet color under the Woodlight. Once a beautiful golden brown fluorescence has been observed from a culture of *M. felineum*.

I restricted my own experiment and observations to the commonest dermatophytos, *M. Audouini*, *M. lanosum*, using for comparison *Achorion gypseum*, *T. purpureum*, *T. violaceum*, and *Epidermophyton interdigitale*.

These few examples should reveal how unreliable the phenomenon of fluorescence is for the determination of species of dermatophytos in the culture.

The fluorescence is first a function of the nutrient mediums. It very probably depends also on the metabolic products elaborated from the changing chemical ingredients by the fungus itself.

*M. Audouini* fluoresced in peach-purple, dark-brown, fawn-brown colors changing with the mediums; different strains of this fungus often revealed changing fluorescence on the same medium.

TABLE I  
ASPECT OF GIANT CULTURES OF SOME DERMATOPHYTONS IN WOODLIGHT

Species	Surface of the growth	Bottom of the media	Nutrient medium used	Age of the culture
<i>M. Audouini</i> No. 152	Peach-purple in the center, dark brown in the periphery	canary-yellow	D S M <sup>1</sup>	9 months
<i>M. Audouini</i> No. 137	Fawn-brown uniformly	canary-yellow	D S Gl <sup>2</sup>	3 months
<i>M. lanosum</i> No. 175	Chalky-white in center, green with deep purple-violet in the periphery	olive-green	O S M <sup>3</sup>	11 days
<i>M. lanosum</i> No. 171	Purple-violet uniformly	olive-green	O S M <sup>3</sup>	11 days
<i>M. lanosum</i> No. 168	Peach-purple uniformly	canary-yellow	D S Gl <sup>2</sup>	11 days
<i>Achorion gypseum</i> No. 145	White, covered up with deep purple-violet	olive-green	O S M <sup>3</sup>	11 days
<i>T. violac.</i>	Greenish-brown	olive-green	O S M <sup>3</sup>	6 months
<i>T. purpureum</i>	Peach-purple	olive-green	D S Gl <sup>2</sup>	7 months
<i>T. purpur.</i>	Purple	green	O S Gl <sup>4</sup>	1 year
<i>Ep. interdigitale</i>	Purple	green	D S Gl <sup>2</sup>	1 year

<sup>1</sup> Difco Sabouraud maltose.

<sup>2</sup> Difco Sabouraud glucose.

<sup>3</sup> Original (French) Sabouraud maltose.

<sup>4</sup> Original (French) Sabouraud glucose.

*M. lanosum* showed the same uncertainty and unreliability. On original (French) Sabouraud maltose agar the color of fluorescence changed from chalky-white to purple-violet, showing a tender peach-purple color on Difco Sabouraud glucose agar.

*Trichophyton purpureum* and *Epidermophyton interdigitale* gave the same purple fluorescence.

We deal with so many variables in the reaction of a fungus growth on any medium, artificial or otherwise, to filtered ultra-violet light (Woodlight) that *at the present time* I cannot but emphasize the *practical uselessness* of the fluorescence phenomenon for determination of species of dermatophytons. In this respect I cannot but substantiate the observations and conclusions of Berde, Mallinckrodt-Haupt and Carrié, Davidson and Gregory.

Livingood and Pillsbury might have found some solution of this complex and complicated problem. Yet, if so, they retained

all the useful information on their own technic which would have enabled the writer and other research workers to substantiate their results. Until such a time we had better consider their statement on the "extreme usefulness of fluorescence light examination of giant cultures for the identification of fungus species" as unwarranted and unsupported by any evidence.

To close the discussion on the diagnostic value of fluorescent phenomenon in tineal infections of the scalp I have to make a few remarks to a statement of Kinnear (31). In his experience *M. Audouini* infected hairs retained their fluorescence under Wood-light indefinitely mounted in liquor potassiae. Davidson and Gregory (27) already contradicted Kinnear's statement. They found that the extraction of the fluorescent substance may readily be demonstrated microscopically for single hairs mounting them dry on a slide and running a drop of 7 per cent potassium hydroxide under the coverslip. The hairs were examined under ultraviolet light. Almost at once the fluorescence in the hair began to fade, while the liquid in which the hair was mounted takes up the fluorescence.

I tried to duplicate both Kinnear's and Davidson and Gregory's experiments. I used 10 per cent and 20 per cent solution of potassium hydroxide (Kinnear did not state the concentration used) and the chlorallactophenol formula 1 and 2. I put single fluorescing hair in a drop of these solutions on a slide covered with a cover-glass. Then the fluorescence was controlled hour by hour for three hours and after 24 hours.

Potassium hydroxide destroyed the fluorescent principle in the hair within three hours, while the intensity of the fluorescence faded out little by little according to the observation of Davidson and Gregory and contrary to the experience of Kinnear. In chlorallactophenol the fading out of the fluorescence of the hair could be seen up to 5 to 6 hours. After 24 hours no fluorescence could be ever seen in these wet mounts.

Dry mounts (1, loc. cit. p. 192), hairs enclosed between two slides and framed with lantern slide tape,—however, preserve the fluorescence of tineal hairs indefinitely. They are rather welcome objects of demonstration at any time if occasion arises.

## SUMMARY

The existence of CARRIERS of the pathogenic agents of tinea capitis is discussed, their number and importance in epidemiology are emphasized.

The use of Woodlight is advocated in detecting the carriers, in establishing the extent of the infection of the scalp, in the control of the progress and efficiency of treatment and in the final determination of a cure.

For the demonstration of fungi on direct microscopic examination the general use of chlorallactophenol formulas are recommended.

The taxonomic individuality of *Achorion gypseum* Bodin, 1907, is upheld in refutation of certain tendencies to make this species synonymous with *Microsporum fulvum* Uriburu, Sabouraud, 1910.

Finally, the availability of Woodlight for the purpose of identification of fungus growth in giant cultures is taken under scrutiny. The unwarranted statement of Livingood and Pillsbury about the extreme usefulness of this physical agent in identification of fungus species is refuted by the experience of other research workers and by the own experiments of the writer.

ARMY OF THE UNITED STATES

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## REPRESENTATIVES OF THE MESOPHELLIA- CEAE IN NORTH AMERICA<sup>1</sup>

S. M. ZELLER

(WITH 6 FIGURES)

*Abstoma reticulatum* Cunningham was previously reported from California.<sup>2</sup> Recently Dr. W. H. Long has sent a specimen of a new *Abstoma* from New Mexico and there is also presented here a new genus, all of the three species of which are from far western states. This paper accordingly brings together descriptions of all of these representatives of the new family, *Mesophelliaceae*, as they occur in North America.

1. ABSTOMA RETICULATUM Cunningham, Linn. Soc. New So. Wales Proc. 52: 242-243. 1927.

Fructifications depressed-globose, up to 6 cm. broad; peridium of two layers, exoperidium very thin or up to 2 mm. thick, fragile, fugacious, whitish or brownish, composed of hyphae intermixed with particles of earth or sand, sometimes merely a meshy hyphal layer covering the endoperidium, which is smooth, dark-colored, mostly umber or sepia-brown, tough, membranous, dehiscing by irregular rupture; gleba at first yellowish, then olivaceous with purplish tints, powdery; capillitium tinted, thin-walled; spores globose, 8-12  $\mu$  in diam., dark brown, distinctly reticulate.

Under or on duff under cypress or fir, central and northern California. January to July.

Specimens examined: California; Monterey county, Point Lobos, near Pacific Grove, *Gertrude S. Burlingham*, 7, January 6, 21 and 22, March 26, 1937; Siskiyou county, near Horse Camp on Mt. Shasta, *Wm. B. Cooke*, 14642, July 8, 1940.

The specimens from Mt. Shasta are referred here with some hesitancy because they are quite young.

<sup>1</sup> Published as Technical Paper No. 439, with the approval of the Director of the Oregon Agricultural Experiment Station. Contribution from the Department of Botany.

<sup>2</sup> Zeller, S. M. Further notes on fungi. *Mycologia* 33: 196-214. 1941. (See p. 213.)



## 2. *Abstoma Longii* sp. nov.

Fructificationes depresso-globosae, obscure brunneae, 2 cm. crassae; exoperidio tenuo terroso, difficiliter separabilis; endoperidio membranaceo, sed duro et rigido; gleba primo molli dein obscure brunnea, floccoso-pulverulenta; capillitio tincto vel hyalino, flaccido; sporis globosis, obscure brunneis, echinulatis,  $26.2\text{--}28.75\ \mu$  (cum aculeis); aculeis  $3.7\text{--}5\ \mu$  longis, mollis, flexuosis, confertis.

Fructifications depressed globose, dark brown, up to 2 cm. in diam.; exoperidium thin with sand inclusions, mostly persisting; endoperidium papery thin, but hard and shell-like; gleba at first soft, then dark-sepia and flocculent, powdery; capillitium tinted or almost hyaline, threads short, fragmentary, flexuous; spores spherical, dark-brown, echinulate,  $26.2\text{--}28.75\ \mu$  including echinulae, which are  $3.7\text{--}5\ \mu$  long, close together, softish or flexuous.

In open sandy mesquite dunes, Jornada Range Experiment Station, about 23 miles from Las Cruces, Dona Ana county, New Mexico, *W. H. Long*, 8310, Nov. 11, 1918, *type*.

## *Radiigera* gen. nov.

Fructificationes hypogaeae vel epigaeae, subglobosae; peridio duvel triplici; basis sterilis pulvinatis; capillitium fasciatans ad columellam basalam spongiosam percursum radians; gleba primo albida, molli, succoso-subcarnosa, postremo obscure brunnea vel atra, pulverulenta; basidiis subglobosis. Vel pyriformis, fasciatis, pendere ex radiant hyphae, quadri- vel multisporis; sporis obscure brunneis, sphaericis, verrucosis vel echinulatis.

Fructifications hypogeous or epigeous, subglobose; peridium of 2-3 layers; thickened sterile base supporting a spongy pulvinate to subspherical columella or core from which the capillitium fibrils radiate to the endoperidium; gleba at first white, soft, succulent to subfleshy, becoming black or dark-brown and powdery at maturity; basidia pyriform to subglobose borne in groups along radiating hyphae, 4-many-spored; spores colored, spherical, verrucose to echinulate.

The type species is *Radiigera fuscogleba* Zeller.

The genus *Radiigera* (to bear or exhibit radii) in the Gastromycetes is essentially the counterpart of some of the higher Plectascales, such as *Elaphomyces*. *R. atrogleba* especially reminds one of *Elaphomyces* both externally and internally; externally because of the matrix-like or mycelial-spawn-like coating, and internally because of the black, powdery gleba with cottony

or evanescent core or columella. The spores are also similar to those of species of *Elaphomyces*.

The gelatinous nature of the endoperidium in fresh specimens sets the genus off from other related genera except *Mesophellia* of which Cunningham<sup>3</sup> says "The endoperidium is . . . composed of a pseudoparenchyma of closely woven, partly gelatinized hyphae."

In *Mesophellia* the central core of the gleba is compact and cheesy in consistency and is held in a central position by strands of the same tissue which extend to and are firmly attached to the inner wall of the endoperidium. In *Radiigera*, the core is essentially a subspherical columella which usually crowns the apex of the sterile base. In *R. atrogleba*, although attached at first, this core may become free or entirely collapsed or evanescent. In all three species the columella (core) is very delicate, either cottony or a soft pithy parenchyma.

*Radiigera* is similar to *Abstoma* in several respects. There is no apical mouth in the endoperidium, dehiscence occurring through the gradual weathering or breaking up of these membranes. The capillitium is unbranched and the spores are spherical.

The structure of the gleba in *Radiigera* is very similar to that of *Geastrum*. The gleba outside of the conspicuous columella or basal core is composed essentially of radiating fascicles of hyphae and capillitium arranged to simulate tubes which reach from the columella to the endoperidium. These fascicles are attached at both ends but in *R. fuscogleba* they separate readily from the endoperidium while in *R. atrogleba* they may separate from both, the columella and the endoperidium. Sections of young dried fructifications, cut tangentially across the fascicles in tube-like arrangement, reveal nothing which could be construed as true tramal tissues. The origin and development of the radial fascicles must be learned through the study of histological preparations of very young fructifications, however, before exact interpretations may be made.

Basidia are borne in groups along the hyphae which are included in the radiating glebal fascicles. Each group of basidia may originate more or less directly from the radial hyphae or are

<sup>3</sup> Loc. cit. p. 313-314.

borne on short hyphal branches. This arrangement of basidia is very similar to that illustrated by Fischer<sup>4</sup> for the basidia of *Podaxis*. The basidia of *Radiigera* are broadly pyriform with several spores as found in some other genera like *Calostoma*, *Sphaerobolus*, or *Lycogalopsis*. The spores are sterigmate.

The capillitium is long and mostly unbranched. In *R. fusco-gleba* the filaments are variable, dark, flexuous, walls uneven, sometimes almost moniliform. In *R. atrogleba* the capillitial filaments are smooth and almost glistening, somewhat wavy, dark. In *R. Taylorii* there are two sizes of capillitial hyphae, which are only slightly colored.

To place a genus like *Radiigera* in its correct taxonomic position presents a perplexing problem because of its diversified affinities, and the lack of knowledge concerning the developmental morphology and the manner in which basidia are borne in some of the apparently affiliated genera. The simple course of basing the classification entirely upon the characters that may be seen in mature fructifications is misleading, but undoubtedly our present incomplete knowledge of the origin and morphology of the glebal tissues of many described Gasteromycetes will probably lead to imperfections in any systematic plan which may be chosen for these fungi.

In 1933 Fischer<sup>5</sup> devised a plan for the Gasteromycetes based on morphological development and the manner in which the basidia are borne. In this plan the genera which have apparent affinities with *Radiigera*, namely, *Abstoma*, *Castoreum*, *Gastrum*, and *Mesophellia*, have been referred to four distinct families, although *Castoreum* and *Mesophellia* were placed under "genera doubtfully included or imperfectly known."

Working independently at the same time and without Fischer's knowledge Cunningham<sup>6</sup> devised a plan which we believe more nearly satisfies this particular group of genera, especially *Abstoma*, *Castoreum*, *Mesophellia*, and *Radiigera*. His plan included

<sup>4</sup> Fischer, Ed. Gastromycetae. E. & P. Nat.-Pfl. 7a: p. 118. fig. 91A and B. 1933.

<sup>5</sup> Loc. cit.

<sup>6</sup> Cunningham, G. H. The Gasteromycetes of Australasia XV. The genera *Mesophellia* and *Castoreum*. Linn. Soc. New So. Wales Proc. 57: 313-322. illus. 1932.

the tribe *Mesophelliaceae*, with tribes *Lycoperdeae* and *Geastreae* in the family *Lycoperdaceae*. It would seem, however, that Fischer's scheme for suborders and families is more feasible from the morphological viewpoint. It is proposed to combine the two ideas therefore and to include the *Mesophelliaceae* in the suborder *Lycoperdineae* (sensu Fischer). The *Mesophelliaceae* would therefore contain the genera *Abstoma*, *Castoreum*, *Mesophellia*, and *Radiigera*.

The systematic key will be as follows:

#### Suborder: LYCOPERDINEAE

- I. Ectoperidium not opening stellately at maturity.
  - A. Peridium 2-layered, dehiscing by an apical stoma (irregular or wanting in *Calbovista*, *Calvatia*, and *Mycenastrum*); capillitium attached or free, simple or freely branched. . . . 1. LYCOPERDACEAE.
  - B. Peridium 2-3-layered, indehiscent, or rupturing irregularly at apex; capillitium unbranched. . . . . 2. MESOPHELLIACEAE.
- II. Ectoperidium opening stellately at maturity; peridium usually 4-layered, endoperidium dehiscing by an apical stoma; capillitium attached, unbranched. . . . . 3. GEASTRACEAE.

The genera in *Lycoperdaceae* and *Geastraceae* may be classified as in Fischer except the genera as included in the *Mesophelliaceae* below.

#### **Mesophelliaceae** fam. nov.

Peridium usually 3-layered, indehiscent or rupturing irregularly at the apex; capillitium unbranched; spores globose or ellipsoid, variously roughened or with a gelatinous sheath; basidia inflated, sterigmate.

#### KEY TO GENERA

Spores spherical, echinulate, reticulated or verrucose.

Gleba without a sterile base. . . . . 1. *Abstoma*.

Gleba with a sterile base. . . . . 2. *Radiigera*.

Spores ellipsoid, smooth or irregularly roughened.

Gleba with a central core. . . . . 3. *Mesophellia*.

Gleba without a central core. . . . . 4. *Castoreum*.

So far as known *Castoreum* and *Mesophellia* do not occur in North America.

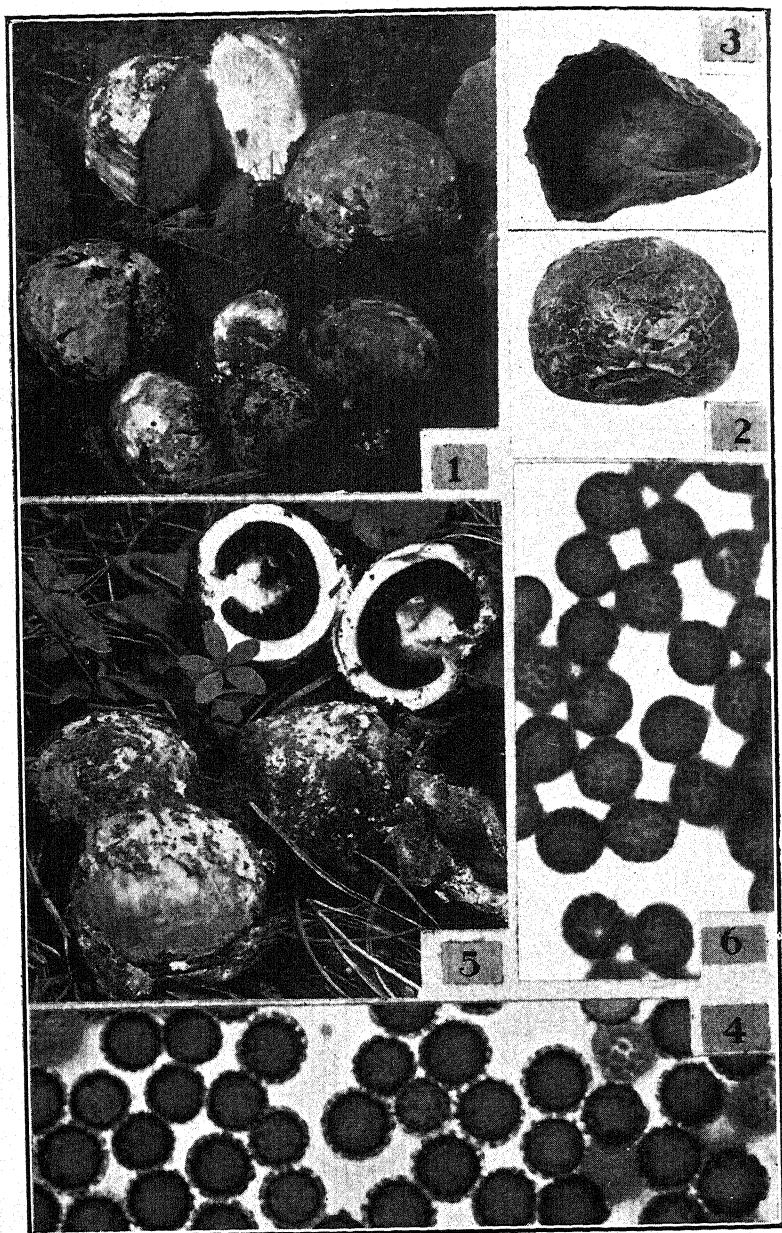


FIG. 1. Several fructification of *Radiigera fuscogleba* in natural habitat. Slightly reduced from kodachrome by Wm. B. Gruber. FIG. 2. Dried specimen from the type collection of *R. fuscogleba*. Note reticulate wrinkling of

1. *Radiigera fuscogleba* sp. nov.

Fructificationes subglobosae, 4–8 cm. crassae, basi saepe radicans; superficie alba vel isabellina, saepe leniter purpurans, ligno-brunnea vel pallidior siccata, laevi, saepe innato-reticulato-fibrillosa; basis sterilis crasso-conica; columella subglobosa, mollo-spongiosa vel byssoidea, 5–8 mm. crassa; peridio tristratoso, facile a glebo separabili siccato; ectoperidio duplici, strato externo tenui, filamentoso, strato interno (primo) subhyalino, parenchymato, 1 mm. crasso, tenuissimo siccato; endoperidio 2 mm. crasso, subgelatinoso, parenchymato, duro siccato; gleba alba, dein olivaceo-brunnea, funiculi hypharum capillitiumque composita, ad columellam percursum radians; capillitium obscure, simplicis, flexuosum, inaequalum,  $2.7\text{--}3.2\ \mu$  crassum; hyphis radiarum subhyalinis, ramis brevis, basidiophoris; basidiis crasso-pyriformibus, 4-multisporis, brevi-sterigmatibus; sporis brunneis, globosis, alveolato-echinulatis,  $4.7\text{--}5.2\ \mu$ , echinulae subtruncatae.

Sub foliis putridis in pinetis. Oregon, Amer. bor.

Fructifications subglobose 4–8 cm. in diam., with a distinct slightly projecting basal attachment; surface white to old gold or isabella color, sometimes with purplish tints, drying wood brown or lighter, smooth but sometimes with innate reticulate fibrils; sterile base broadly conic in vertical section, crowned by a subspherical columella which is soft, pithy toward the center and more cottony farther out, 5–8 mm. in diam.; peridium of 3 layers, not readily separating from each other but separating from gleba on drying; outer very thin layer (or surface pelt) filamentous, main ectoperidial layer of light-colored, large-celled parenchyma, about 1 mm. thick, drying to papery thinness; endoperidium of dark, large-celled and thin-walled parenchyma, somewhat gelatinous, 2 mm. thick, drying to thin, flinty hardness, inner surface a very thin filamentous layer of hyphae very similar to capillitium; gleba white throughout at first, drying olive brown, com-

surface resulting from drying. These wrinkles follow more or less the reticulate fibrils over the surface. About natural size. FIG. 3. Vertical section of a fructification of *R. fuscogleba* in the type collection. Note sterile base crowned by a globular columella of two textures and tones, the central lighter colored and pithy, the outer zone slightly darker and more cottony. Note also the radiating fascicles from the columella to the endoperidium. About natural size. FIG. 4. Spores of *R. fuscogleba*. Note the alveolate-echinulate epispore.  $\times 2000$ . Photograph by F. P. McWhorter. FIG. 5. Several fructifications of *R. atrogleba* in natural habitat. This shows three fructifications enveloped in a more or less common ectoperidium as described in the text. There is also a vertical section of a sporophore showing spherical columella, black gleba with radiating fascicles, and thick peridium, with more or less easily separable ectoperidium. Slightly reduced from kodachrome by Wm. B. Gruber. FIG. 6. Spores of *R. atrogleba*.  $\times 2000$ . Photograph by F. P. McWhorter.

posed of radiating fascicles of hyphae and capillitium arranged to simulate tubes, fascicles attached to the columella and inner wall of endoperidium, readily separating from latter on drying; capillitium dark, unbranched, flexuous,  $2.7-3.2\ \mu$  in diam., walls uneven, sometimes almost moniliform; fascicular hyphae small, almost hyaline, with short branches, all basidia-bearing; basidia broadly pyriform, 4-many-spored, with short sterigmata; spores dark, spherical,  $4.7-5.2\ \mu$ , alveolate-echinulate, echinulae somewhat truncate, often connivent at their apices.

Hypogeous or epigeous in duff of coniferous forest, Mt. Scott, Portland, Multnomah county, Oregon, collected by *Wm. B. Gruber* (No. 8), July 1943, **type**, and embedded in a thoroughly decayed log (ash?), Jefferson, Marion county, Oregon, *H. C. Gilbert*, Sept. 1929 (both in Zeller Herb.).

## 2. *Radiigera atrogleba* sp. nov.

Fructificationes depresso-globosae, infra umbilicatae, 3.5-5 cm. crassae, 2.5-3.8 cm. altae, exoperidium completum, confluenso stromatiforme individuorum complurium commune, crassum, compactum, coactile, ab endoperidio subfacile separum; superficie hebeti, inaequali, albi, canescenti, siscatate "tilleul-buff" vel "light vinaceous fawn" vel "buckthorn brown"; endoperidium 4-5 mm. crassum, albidum vel pallido-viridum, duplex, strato externo circa 1 mm. crasso, compacto prosenchymatibus, strato interno circa 3-4 mm. crasso subspungioso parenchymatibus; columella subglobosa, 10-15 mm. crassa, alba, canescenti, siccitate obscuriore, byssiodo-parenchymatam composita, saepe collabente, basi sterili pulvinati insedente; gleba atra, pulverascens; capillitio hyphisque basidiophoris columellae superficiei internae endoperidioque adnato, simplicio, laxo, obscuro,  $2.5-3\ \mu$  crasso; hyphis basidiophoris hyalinis, ramis brevis, parvis; basidiis latopyriformibus, 4-multi-sporis; sporis obscure, subglobosis, verrucosis,  $5.6-6.2\ \mu$ .

In terram arenosam subimmersum, prope McCall, Idaho, Amer. bor.

Fructifications depressed-globose, umbilicate under the slight sterile base, 3.5-5 cm. broad and about  $\frac{3}{4}$  as high, several fructifications together may be embedded in a very conspicuous spawn-like mycelial mat, as well as a heavy felty, compact layer immediately surrounding the sporophores which also constitutes the exterior layer of the peridium (ectoperidium); ectoperidium surface felty, dull, rough, white to grayish at first, drying tilleul-buff to light vinaceous-fawn or even buckthorn brown, of fine somewhat nodose hyphae, more or less readily separating from the endoperidium which has an even, dull, felty surface with whitish or rosy tints when fresh (or changes to olivaceous tints, such as chamois or isabella color when bruised), drying pale pinkish buff;

endoperidium 4–5 mm. thick, pure white or with pale greenish tints, of two layers, outer about 1 mm. thick, of very compact, small-celled prosenchyma, the inner 3–4 mm. thick of large-celled parenchyma; columella subspherical, 10–15 mm. in diameter, arising from a slightly elevated sterile base, white to grayish, drying darker, of very pithy parenchyma, sometimes evanescent or almost totally collapsed; gleba black, composed of radiating plate-like fascicles of hyphae and capillitium arranged to simulate flattish tubes, fascicles attached to the columella and inner wall of the endoperidium, readily separating from both on drying; capillitium unbranched, smooth, almost glistening, somewhat wavy, dark,  $2.5\text{--}3\ \mu$  in diam.; fascicular hyphae small, hyaline, with short branches, all basidia-bearing; basidia broadly pyriform, 4-many-spored; spores dark, subspherical, verrucose, often with a prominent sterigmatal scar,  $5.6\text{--}6.2\ \mu$  in diam.

Hypogeous or epigeous in sandy soil of a creek bed among tamarack and white pine, near McCall, Valley county, Idaho. Collected by *Wm. B. Gruber* (No. *P-20*), Aug. 20, 1943, **type** (in Zeller Herb.).

Mr. Gruber has furnished the following field notes on *Radiigera atrogleba*: "The outer crust tough and hard like wood when dry. The black core (*gleba*) radiates from the center and from below. The black material consists of an ink-like substance, staining everything but it washes off easily with water. Odor metallic, resembling that of actual ink. The puff balls appear in closely connected, almost ingrown, clusters of from 15 to 30. They are deep in the soil and only a few of the balls are visible. When 'unearthed' the cluster of puffballs is found to be protected by a fragile, thin, mycelial mat which envelopes the whole cluster except the top part of those exposed to the surface of the ground. I saw the plant only in mature stages of development, however, and it appeared as though the mycelial spawn might have completely enveloped the balls in younger stages. Later stages of development show that the black juice changes to a dry spore powder."

The illustration of the spores (FIG. 6) shows the verrucose nature of the episore as well as the sterigmatic scar in a few cases. At the base of the spore the verrucae radiate from the sterigmatic scar.



3. *Radiigera Taylorii* (Lloyd) Zeller, comb. nov.

*Mesophellia Taylorii* Lloyd, Myc. Notes 73: 1305. fig. 2914. 1924.

Fructifications subglobose, 2–3 cm. in diam., with a distinct rooting basal scar; surface drying dull drab or lighter, even, smooth or slightly velutinate; sterile base white, pulvinate in vertical section, crowned by a subspherical, white, cottony-soft columella, sometimes detached from the base as a free core, sometimes almost evanescent; peridium of two closely adnate layers which become easily separable when dry; exoperidium egg-shell thin when dry, cartilaginous; endoperidium white, gelatinous, about 3–4 mm. thick when fresh, drying very thin and light buff; gleba buffy-brown; capillitium in fascicles of long, parallel, non-branched filaments, fascicles extending radially from columella to endoperidium, composed of capillitial filaments and basidiophorous hyphae; capillitial filaments hyaline to slightly straw-colored, some large, up to 4  $\mu$  in diam., usual ones smaller, 2–2.5  $\mu$  in diam., apparently not branched; basidia borne in groups along the radiating hyphae, pyriform, up to 11- or 12-spored; spores sphaerical, slightly straw-colored to very light brown in mass, slightly verrucose, 2.5–3.75  $\mu$ .

Hypogeous under loose leaf mould of redwood near Eureka, Humboldt Co., California. Summer. The type was collected by C. Wilder Taylor (In Lloyd Collections, Smithsonian Inst., and in Zeller Herb.).

Under date of Sept. 30, 1924, the writer received the following note from Mr. C. G. Lloyd: "I enclose specimen that should be of interest to you. It will be published in the next issue of my notes, now in the printer's hands." He referred to a part of the type of *Mesophellia Taylorii* Lloyd. Mr. Lloyd was never satisfied with his reference of this species to the genus *Mesophellia*, according to his personal statement to the writer as well as to his comment on a later collection,<sup>7</sup> as follows: "Our American plant will no doubt be called a new genus in time," on the grounds of the soft, "cottony core, globose spores, and gelatinous endoperidium" . . . which are not to be found in other species of *Mesophellia*.

<sup>7</sup> Stevenson, J. A., and Edith K. Cash. The new fungus names proposed by C. G. Lloyd. Lloyd Library & Museum Bull. 35 (Mycological Ser. No. 8): 189. 1936.

Dodge,<sup>8</sup> who erroneously included *Mesophellia* in the Plectascales, excluded *M. Taylorii* from that genus on the same grounds as Lloyd had mentioned and further suggested its similarity to "juvenile, unexpanded stages of some puff-ball." Cunningham<sup>9</sup> believed "*M. Taylorii* was erected upon an unexpanded *Geaster*."

It differs, however, in several characters from *Geaster* and *Astraeus*, although it has some other characters in common with the former, and Mr. Lloyd, we believe, was too keen a student of *Geaster* to have made that mistake. There were several fructifications in each of the two collections received by Lloyd from California. None of them have an apical pore in the endoperidium, nor does the exoperidium divide regularly into astral rays. Both peridial layers break up irregularly. The fructifications accordingly remind one of *Abstoma*.

As soon as the writer received the specimens of *Radiigera fuscogleba* and *R. atrogleba* he was immediately reminded of their similarity to *Mesophellia Taylorii* Lloyd, and the three species have proved to possess likenesses enough to constitute a generic concept.

#### KEY TO SPECIES OF RADIIGERA

Spores echinulate, gleba brown.....1. *R. fuscogleba*.  
Spores verrucose.

Spores 5.6-6.2  $\mu$ , exoperidium a heavy felt-like layer,  
gleba black at maturity.....2. *R. atrogleba*.  
Spores 2.5-3.7  $\mu$ , exoperidium thin, cartilaginous when  
dry, gleba light brown or creamy.....3. *R. Taylorii*.

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<sup>8</sup> Dodge, C. W. The higher Plectascales. Ann. Myc. 27: 156. 1929.

<sup>9</sup> Cunningham, G. H. Gasteromycetes of Australasia. XV. The genera *Mesophellia* and *Castoreum*. Linn. Soc. New So. Wales 57: 313-322. illus. 1932.

## BRAZILIAN CHYTRIDS IV. SPECIES OF ROZELLA

JOHN S. KARLING

(WITH 28 FIGURES)

Among the numerous saprophytic chytrids found by the author (1944 a, b, c) in water and soil cultures collected from various parts of the Amazon Valley in Brazil, occurred six intramatrical species which parasitize the mycelium or sporangia of *Pythium*, *Achlya*, *Cladochytrium*, *Endochytrium*, *Rhizophlyctis*, and *Rhizophydium*. These parasites belong in the genus *Rozella* of the family Olpidiaceae, and five of them have been recorded previously from the United States. The sixth species, however, has not been found outside of Brazil and appears to be a new species. The discovery of these hyperparasites in South America indicates that the genus *Rozella* is widely distributed geographically as well as in host range.

At the present time species of this genus are segregated in two groups on the basis of whether or not the thallus divides into several segments which subsequently develop into sporangia or resting spores and become delimited by cross walls in the host cell. In the monosporangiate nonseptigenous group, the thallus forms one sporangium or resting spore and stimulates hypertrophy but not multiseptation of the host cell. The second group embraces the septigenous polysporangiate species in which the thallus is reported to cleave into segments which become delimited by the formation of host cell walls between them, mature in basipetal succession, and develop into sporangia or resting spores. So far thirteen monosporangiate and three polysporangiate species have been recorded in mycological literature. Of the species collected in Brazil, five belong in the former and one in the latter group.

### NONSEPTIGENOUS MONOSPORANGIATE SPECIES

#### 1. *ROZELLA LAEVIS* (FIGS. 1-19).

This species was previously found by the author (1942 b) as a parasite in *Pythium gracile* in Virginia and diagnosed as a new

species on the basis of its hyaline, smooth resting spores. In Brazil it occurred in an unidentified species of *Pythium* from a soil culture collected at São Carlos, Matto Grosso. This host closely resembles *P. gracile*, but its identity has not been definitely established. The parasite also agrees so closely with the one described from Virginia that it is accordingly regarded as the same species. Inasmuch as *R. laevis* was diagnosed only briefly and not illustrated, a further account with figures of its structure and development is presented here. As is most species of *Rozella* its zoöspores are quite small,  $1.5-1.8 \times 2.9-3.3 \mu$ , with a broad posterior and a tapering anterior end (FIG. 1). Occasionally, large abnormal, multiflagellate zoöspores (FIG. 3) are formed as the result of incomplete or unequal cleavage in the sporangium. The normal spores contain a dense globular body or area in the center which appears to be somewhat granular in structure, but is not highly refractive. As the zoöspores approach the end of the active swimming phase, they become oval and taper at the posterior end. Then as they come to rest they round up and become spherical in shape. If the quiescent zoöspore is in contact with a host cell (FIG. 4) it develops a short penetration tube which penetrates the wall. The content of the spore then flows slowly into the host cell as a naked plastic body and becomes more or less obscured by the host protoplasm. The empty spore case remains attached on the outside for a short time, but soon becomes wrinkled, collapses, and disappears as in *R. Cladochytrii* and *R. Rhizophlyctii* (Karling, 1942 a). The newly-entered parasite appears to be closely enveloped by the host protoplasm, and no physical antagonism is visible between the two protoplasts. Within a few hours, however, the host hypha begins to enlarge in the region of infection, and if the parasite lies in or near the tip of a branch the latter usually becomes clavate in shape (FIGS. 5-8). As hypertrophy increases the protoplasm becomes denser and more coarsely granular in appearance (FIG. 5), so that the boundary parasite is obscured. With further enlargement of the host cell, however, numerous vacuoles begin to appear (FIG. 6) in the protoplasm, but as was pointed out by the writer (1942 a) in relation to infection by other species of *Rozella* it is not certain that all of them relate to the parasite. The vacuoles in the center

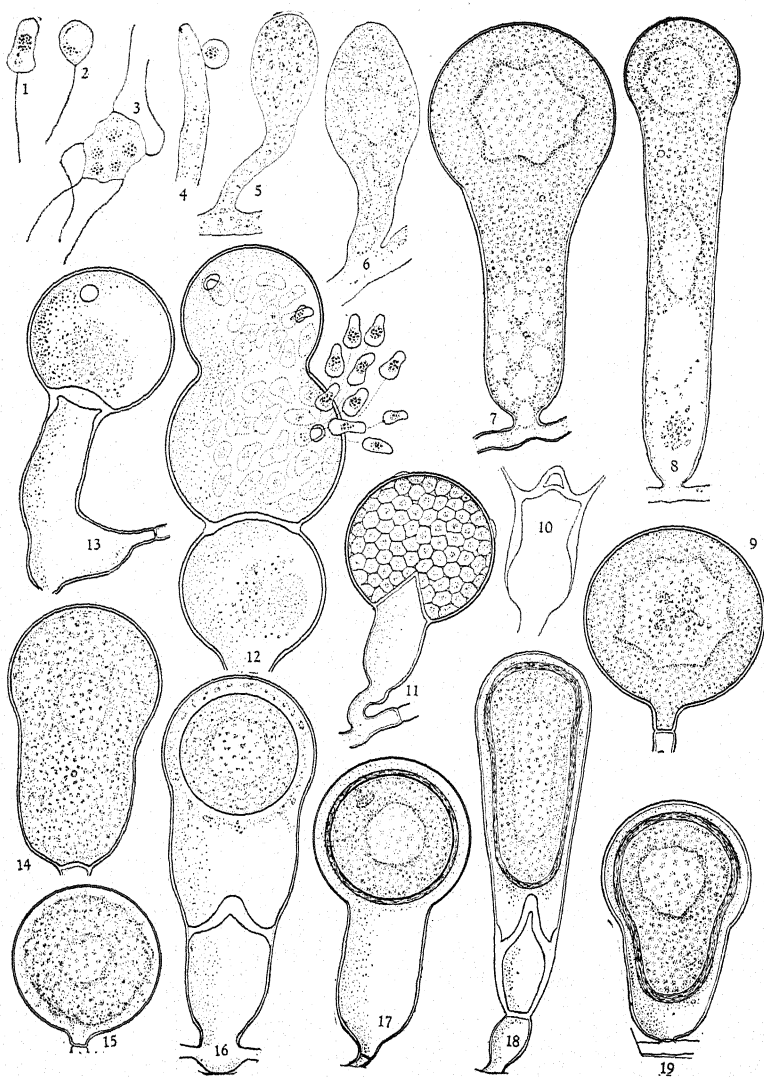
of the swelling later coalesce to form one or more larger ones as shown in figure 7. This figure shows a short hyphal branch which has been transformed into a large clavate swelling under the influence of the parasite. A large irregular vacuole is present in the dense upper part, while in the basal portion the protoplasm is relatively sparse and highly vacuolate. This condition becomes more pronounced as the protoplasm appears to move up and accumulates in the tip, until very little besides the primordial utricle remains in the base (FIG. 8). While these changes are taking place, a granular substance and variously-shaped globules, which look like extraneous waste material, accumulate in the vacuoles of the swollen portion (FIGS. 8, 9) and undergo Brownian movement.

The infected branches and intercalary portions of the host mycelium are usually delimited by cross walls from the rest of the thallus (FIGS. 9, 11, 13, 14, 15, 17, 18, 19), and in the event that such branches are fairly long an additional septum may be formed as the protoplasm accumulates in the tip (FIGS. 11, 12, 13, 16, 18). It is to be emphasized, however, that these septa do not delimit separate segments of the parasite as in cases of infection by septigenous polysporangiate species. The walls thus formed may be almost directly transverse, slight curved or concave-convex (FIG. 12), narrowly or broadly cone-shaped (FIGS. 11, 16, 18) and project upward into the more swollen portion of the branch. They may be comparatively thin (FIG. 11) or greatly thickened (FIGS. 10, 13, 16, 18). Oftentimes the longitudinal walls in the near vicinity of the transverse septa also become greatly thickened (FIGS. 10, 18). In some instances these thickenings were as pronounced as those produced by *R. Rhizophidii*, *R. Apodyae* and *Rozellopsis Waterhouseii* (Karling, 1942 a, c, according to the figures of Cornu (1872) and Miss Waterhouse (1940). *Rozella laevis* thus induces septation of the infected parts and thickening of the walls in addition to causing hypertrophy. The hypertrophy, however, is localized and does not extend very far beyond the region of infection.

As was noted earlier, the *Rozella* parasite is difficult to see in the early developmental stages and may be completely obscured by the host protoplasm. This characteristic has been noted by

most workers on species of the genus, and has led several authors to believe that the protoplasm of the parasite is miscible with and infiltrates that of the host. While this condition may be suggested perhaps by figures 6, 7 and 8, the present writer, nevertheless, believes that the two protoplasts are distinct and immiscible. At maturity the parasite fills the hypertrophied portion which has been delimited by a cross wall, and its sporangium wall apparently becomes so closely applied to that of the host that the two are indistinguishable (FIGS. 9, 11). Figure 9 shows a relatively short branch which has been converted into a sphere and is completely filled by the parasite. The center is occupied by a large stellate vacuole in which lie numerous granules and extraneous material. At this stage of development low inconspicuous exit papillae are formed and project through the host cell wall (FIG. 11). The protoplasm then cleaves into zoospore initials which mature and differentiate in the sporangium. When mature, they begin to move and glide over each other and among the dispersed extraneous granules or bodies. This movement increases in velocity and intensity until the zoöspores are rapidly swirling within the sporangium. The exit papillae then deliquesce and a small amount of hyaline slimy material oozes out and disperses in the surrounding water. Within one or two minutes the zoöspores begin to emerge in a dense stream which may extend for a considerable distance in the water before separation of the individuals occur. The zoöspores thus appear to be surrounded by or embedded in a slimy substance and lie quiescent for a few seconds. As this viscid material disperses they begin to jerk and wriggle about and soon dart away. After the zoöspores have been discharged a considerable amount of extraneous material in the form of granules, globular bodies and slimy substance remains in the sporangium. This material has the same appearance as that which was visible earlier (FIGS. 8, 9) in the large vacuoles, and apparently is waste material discarded by the parasite.

The resting spores of *R. laevis* occur after a period of abundant sporangium and zoospore production. In their development the protoplasm in hypertrophied branches begins to contract from the host wall (FIGS. 14, 15) and develops a distinct wall (FIG. 16) of its own. The incipient spore thus formed is surrounded by a



FIGS. 1-19. *Rozella laevis*. 1, motile zoospore; 2, zoospore at end of motile period; 3, abnormal multiflagellate zoospores; 4, infection of host mycelium; 5, beginning of hypertrophy; 6, later stage of vacuolate protoplasm; 7, large terminal clavate swelling with stellate vacuole at apex; protoplasm sparse and vacuolate in basal portion; 8, later developmental stage; 9, spherical swelling with large central vacuole in which lies extraneous material; 10, basal portion of a hypertrophied branch showing thickening of transverse and longitudinal walls; 11, delimited portion of terminal swelling filled with sporangium

narrow hyaline zone, and this in turn is enveloped by a layer of host protoplasm from which extend fine radial strands of cytoplasm. As the spore matures the wall thickens, while the protoplasm becomes coarsely and uniformly granular with a large vacuole in the center. The fully formed spores may be spherical (FIG. 17), oblong (FIG. 18), or somewhat obpyriform (FIG. 19) in shape and vary considerably in size. These characters are determined to a large extent by the size and shape of the swellings in which the spores occur. So far germination of the spores has not been observed.

As was pointed out in an earlier paper by the writer (1942 b) the resting spores of this species are similar in size to those of *R. cuculus* Butler (1907) which parasitizes *Pythium* sp., *P. intermedium* and *P. monospermum*. However, the spores of *R. laevis* are hyaline, while those of *R. cuculus* are brown to pale yellow in color. Although these species are very similar it is not certain that they are identical. Neither Dangeard (1896), Butler nor Tokunaga (1933) determined the size of the zoöspores of *R. cuculus*, and until this character is known the relationship of the two species will remain questionable.

## 2. ROZELLA CLADOCHYTRII.

This species was found parasitizing sporangia and the more tenuous parts of the rhizomycelium of *Cladochytrium replicatum* which had been collected at São Carlos, Matto Grosso. Only a few diseased thalli were found, and the infection did not attain epidemic proportions. However, enough sporangia, zoöspores and resting spores were available to determine their size, structure and development and to show that the Brazilian fungus is morphologically identical to the one described by the author (1941, 1942 a) from Texas. However, no cross inoculations were made and it is not known whether or not the parasite from Brazil will infect other species of *Cladochytrium* and *Nowakowskiella*.

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and zoöspores of parasite; 12, unusually large septate terminal swelling from which zoöspores are emerging; 13, empty sporangium with extraneous residue; 14, 15, stages in resting spore development; 16, young incipient resting spore; 17-19, mature resting spores.



## 3. ROZELLA RHIZOPHLYCTII.

This chytrid was first described as a parasite of *Rhizophlyctis Petersenii* (Karling, 1942 a) although Miss Ward (1939) had previously noted and figured a few resting spores of a parasite in *Rhizophlyctis rosea* which probably relate to the same species. What appears to be *R. Rhizophlyctii* was found by the author in sporangia of *Rhizophlyctis rosea* isolated on bits of onion skin from soil cultures collected in the Acre Territory, Brazil. Unfortunately, *Rhizophlyctis Petersenii* was not available in Brazil for cross inoculation experiments, and it is not certain that the South American fungus will infect this host. Nevertheless, it is so similar in structure and method of development to *Rozella Rhizophlyctii* that the writer regards the two species as identical.

Another *Rozella* parasite was found in an unidentified species of *Rhizophlyctis* collected in moist soil at São Carlos, Matto Grosso. This host differs from *Rhizophlyctis rosea* by the presence of a large hyaline refractive globule in the zoöspores, and appears to be a new species. Its parasite, on the other hand, is identical to *Rozella Rhizophlyctii* in structure and method of development and will infect *Rhizophlyctis rosea*. However, no opportunity was available to test its pathogenicity to *Rhizophlyctis Petersenii*. The author, nonetheless, believes it is identical to *R. Rhizophlyctii*.

## 4. ROZELLA ENDOCHYTRIUM.

This species occurred as a parasite in the sporangia of *Endochytrium operculatum* which had been collected in dead grass leaves from a swamp at kilometer 53 on the Madeira-Mamoré railroad in the Matto Grosso. Like *R. Rhizophlyctii* this parasite does not cause hypertrophy or septation of the host sporangia. It differs primarily from the former species by the structure of its zoöspores and the fact that it is limited in host range to *E. operculatum* as far as is now known. Resting spores are unknown in this species, and none was found in the material from Brazil. The Brazilian parasite, nevertheless, agrees in all respects with the species found by the author (1941) in Texas, and the two fungi are, therefore, regarded as identical.

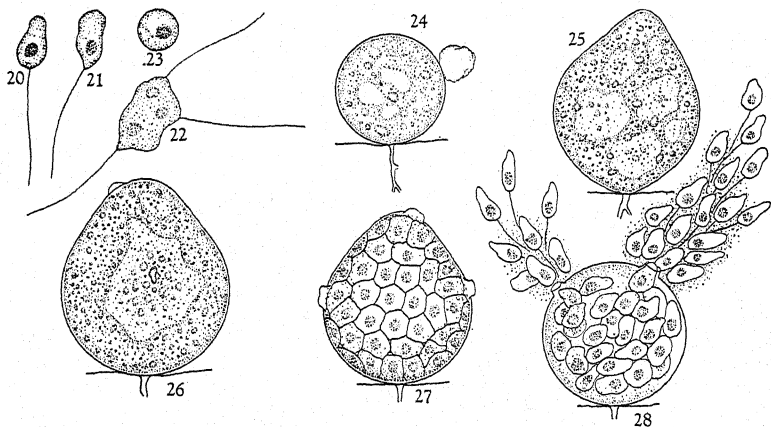
5. *Rozella Rhizophydii* sp. nov. (FIGS. 20-28).

Fungus parasiticus; sporangiis solitariis, longitudinem latitudinemque cellae matricolis in toto complentibus, sphaericis, 15-30  $\mu$  ovalibus, 10-12  $\times$  13-20  $\mu$ , pyriformibus, 12-15  $\times$  16-25  $\mu$  cum 1-3 papillis exeuntibus; pariete sporangii ex cella matricali fere non discernendo. Zoosporiis hyalinis, ovalibus aut obpyriformibus, 2-2.5  $\times$  3-4  $\mu$ ; flagello 12-14  $\mu$  longo. Sporiis perdurantibus non notis.

Sporangia solitary, filling host cell and conforming with the latter's size and shape, spherical, 15-30  $\mu$ , oval, 10-12  $\times$  13-20  $\mu$  or pyriform, 12-15  $\times$  16-25  $\mu$  with 1-3 low exit papillae; wall of sporangium indistinguishable from that of host. Zoöspores hyaline, oval or slightly pyriform, 2-2.5  $\times$  3-4  $\mu$ ; with a small globule near the posterior end; flagellum 12-14  $\mu$  long. Resting spores unknown.

Parasitic in *Rhizophyidium globosum*, Manaus, Amazonas.

This species occurred in the sporangia of *Rhizophyidium globosum* which in turn was parasitizing *Xanthidium subhastiferum*



FIGS. 20-28. *Rozella Rhizophydii*. 20, 21, motile zoöspores of *R. Rhizophydii*; 22, abnormal triflagellate zoöspore; 23, zoöspore after coming to rest; 24, infection of host; 25, 26, development of parasite inside of host sporangium; 27, host sporangium filled with zoöspores of parasite; 28, discharge of zoöspores.

in the swimming pool of the Bosque Club at Manaus. As far as is now known it appears to be an obligate parasite of this host, because all attempts to transfer it to *R. sphaerocarpum*, *R. pollinis*, *R. carpophilum*, *Endochytrium operculatum*, *Rhizophlyctis rosea*,

*Cladochytrium replicatum*, *C. crassum*, *Nowakowskiella elegans*, *N. ramosa*, *N. elongata*, and *N. granulata*, have failed.

The development and life cycle of this species, as far as it is known, are shown in figures 20 to 28. The structure and shape of the zoöspores (FIGS. 20, 21), method of infection (FIG. 24), development of the thallus within the host (FIGS. 25, 26), cleavage (FIG. 27), liberation and behavior of the zoöspores (FIG. 28) are so similar to those previously described for *R. Rhizophlyctii* and *R. Endochytrii* that very little can be added to the accounts already given. Like both of these species, *R. Rhizophyidii* does not cause marked hypertrophy and distortion of the host cell nor thickening of its walls. Resting spores have not been found, so that comparisons on the basis of this character cannot be made at present. However, the zoöspores of *R. Rhizophyidii* are slightly larger than those of either of the two former species. This difference coupled with the fact that the Brazilian parasite did not infect *Rhizophlyctis* and *Endochytrium*, leads the author to the conclusion that *R. Rhizophyidii* is a distinct species.

#### SEPTIGENOUS POLYSPORANGIATE SPECIES

##### ROZELLA ACHLYAE.

So far this is the only polysporangiate species found in Brazil. What appears to be the same fungus was previously reported but not named by the author (1942 b, p. 204) as a parasite of *Achlya* in New York. Later in the same year Shanor (1942) gave a brief account of its development in *Achlya flagellata* and named it *R. Achlyae*. In Brazil it was found in the sporangia of the same host which had been isolated in water cultures from Rio Negro at Manaus, Amazonas. The size, shape and structure of the zoöspores, development of the sporangia and resting spores, and the effects produced in the host cell are similar to those described by Shanor, and there is no doubt in the author's mind that the two fungi are identical. This view is further supported by the fact that the Brazilian parasite also is limited in host range to *Achlya flagellata*.

#### SUMMARY

Five monosporangiate species of *Rozella*, *R. laevis* in *Pythium* sp., *R. Cladochytrii* in *Cladochytrium replicatum*, *R. Rhizophlyctii*

in *Rhizophlyctis rosea* and *Rhizophlyctis* sp., *R. Endochytrii* in *Endochytrium operculatum*, and *R. Rhizophydii* in *Rhizophydium globosum*, were found in Brazil. *Rozella Rhizophydii* has fairly large zoöspores and is limited in host range to *Rhizophydium globosum*. It is accordingly diagnosed as a new species, although its life cycle is not completely known. In addition to these monosporangiate parasites, one polysporangiate species, *R. Achlyae*, was found in the sporangia of *Achlya flagellata*.

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## MYCOSPHAERELLA TULASNEI IN APPLE AND PEAR ORCHARDS

J. R. KIENHOLZ<sup>1</sup>

The relationship between *Cladosporium herbarum* Link and *Mycosphaerella Tulasnei* Jancz. was confirmed by Ruehle.<sup>2</sup> He produced the ascigerous form of the fungus by inoculating sterilized wheat leaves with the *Cladosporium* stage. The occurrence of perithecia on fallen apple and pear leaves appears not to have been reported.

In cold storage the fungus produces a slow rot of apple fruits and a more rapid rot of ripe pears. It may cause a blossom rot during heavy fogs in Russia according to Balakhonoff,<sup>3</sup> and occurs as a saprophyte almost everywhere. Perithecia of the fungus have commonly been observed in the spring on overwintered apple and pear leaves at Hood River, Oregon, since 1932. Partially developed perithecia were less frequently observed to develop in scurfy areas below buds on pear shoots which had grown rapidly during the past season. Typical *Cladosporium herbarum* cultures were obtained from ascospore isolations of this material and perithecia were again produced from cultures on sterilized leaves of wheat, apple, and pear in culture.

The following measurements and notes are based on fresh naturally occurring fruiting bodies from overwintered apple and pear leaves:

*Perithecia*: 100–160  $\mu$  wide by 150–250  $\mu$  deep; immersed in the leaf tissue from  $\frac{1}{4}$  to  $\frac{1}{3}$  of their depth; present on either leaf surface not in contact with the soil.

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<sup>2</sup> Ruehle, G. D. New apple-rot fungi from Washington. *Phytopath.* 21: 1141–1152. 1931.

<sup>3</sup> Balakhonoff, P. I. (Note on the dying off of fruit tree blossoms on the Black Sea Littoral in connection with fogs.) *Bull. North Caucasian Plant Prot. Station, Rostoff-on-Don.* 1930: 169–172. 1930. *Abs. in Rev. Appl. Mycology* 10: 605. 1931.

*Asci*: 32–107  $\mu$  by 11–27  $\mu$ ; mean 67.2  $\mu$  by 17.4  $\mu$ .

*Ascospores*: Typically 2-celled; 11–29  $\mu$  by 4–9  $\mu$ ; mean 21.6  $\mu$  by 7.9  $\mu$  (top cell) to 6.4  $\mu$  (bottom cell); hyaline to pale olivaceous brown when older.

3-celled; mean 25.5  $\mu$  by 8.0  $\mu$ .

4-celled; mean 28.3  $\mu$  by 8.5  $\mu$ .

The ascospores usually become 3- to 4-celled during germination. Conidia produced in cultures or on fruit tissue were variable in shape, almost globose to narrowly ellipsoid; 1- to 3-celled; up to 30  $\mu$  in length; with a finely echinulate spore wall.

Specimens have been deposited in the mycological collections of the Bureau of Plant Industry, Soils, and Agricultural Engineering, Beltsville, Maryland.

# ZOÖSPOROGENESIS IN THE RESISTANT SPORANGIA<sup>1</sup> OF ALLOMYCES ARBUSCULUS

WINSLOW R. HATCH<sup>2</sup>

(WITH 2 FIGURES)

## INTRODUCTION

Our knowledge of the morphology of the resistant sporangia of *Allomyces arbusculus* can be quickly and thoroughly appraised by reviewing those facts which Emerson presented in his last paper (1941) but which, of necessity, he had to scatter through the many sections of his fine paper.

The resistant sporangia of *Allomyces arbusculus* are "more or less ovoid—with a flat, sometimes truncate, base. They are formed within the original hyphal membrane but are not fused to it and have a two-layered wall of their own, the outer of which is—thickened and brown."<sup>3</sup> The thick, outer wall possesses "fine, closely spaced pits" which are "distinct—averaging 1  $\mu$  apart." The "normally tawny to reddish brown" color of the resistant sporangia is "probably" caused by "a melanin-like substance." The resistant sporangia are "20–81  $\mu$ " in length; "16–60  $\mu$ " in width. They are "always produced in abundance" (on the asexual plant). "They are formed terminally—later becoming sympodially arranged; very rarely intercalary or in short chains." "Zoösporangia are normally formed first on young hyphae; heavy-walled (resistant) sporangia appear somewhat later depending on environmental conditions."<sup>4</sup>

In the dehiscence of resistant sporangia the thick outer wall cracks longitudinally. The "cracking of the outer wall is evidently a result of pressure from within, and the content, sur-

<sup>1</sup> While the term zoösporangia is undoubtedly the more correct word, the term "sporangia" is retained. For terminology see Emerson, 1941, p. 89.

<sup>2</sup> Part of this study was made at Dartmouth College, Hanover, New Hampshire.

<sup>3</sup> Emerson, 1941.

<sup>4</sup> Emerson, 1941.

rounded by a thin inner membrane, may continue to swell until it becomes more than twice its original diameter. One to four or occasionally more discharge papillae are formed, exactly similar to those on the zoösporangia and gametangia. Germination (= dehiscence), when once initiated, takes place within a short period, often less than sixty minutes after splits first appear in the outer wall. After most of the spores (= zoöspores) have emerged, the thick elastic outer wall of the sporangium frequently closes in again almost regaining the position which it originally occupied at the start of germination (= dehiscence). In so doing it may crumple the thin inner membrane and trap a few of the spores (= zoöspores) still remaining within.”<sup>4</sup>

“These results indicate that reduction divisions and segregation of the parental characters take place after the formation of resistant sporangia on the sporophyte and before the development of mature gametophytes.”<sup>5</sup>

While the writer (Hatch, 1938) questioned this interpretation, suggesting that meiosis occurred in the germination of the zygote, a more careful analysis of his material, to be reported upon in another paper, has convinced him that there is really no evidence for meiosis at zygote germination.

The process of zoösporogenesis in resistant sporangia on asexual (sporophytic) plants is a critical process, because meiosis occurs during zoösporogenesis and because the sexual or asexual condition of the plants derived from R. S. zoöspores<sup>6</sup> is apparently determined during zoösporogenesis. As has been suggested above, we know a good deal about the morphology of resistant sporangia. We know something of the process of dehiscence, a stage in zoösporogenesis, but we need to know more about the morphology, cytology and physiology of zoösporogenesis in resistant sporangia. This paper constitutes the first of a series dealing with this process.

#### MATERIAL AND METHOD

The source of the material used in this study was *Allomyces arbusculus*, North Carolina isolate No. 2.<sup>7</sup> The resistant spor-

<sup>5</sup> Emerson, 1941.

<sup>6</sup> Zoöspores from resistant sporangia, Emerson's abbreviation.

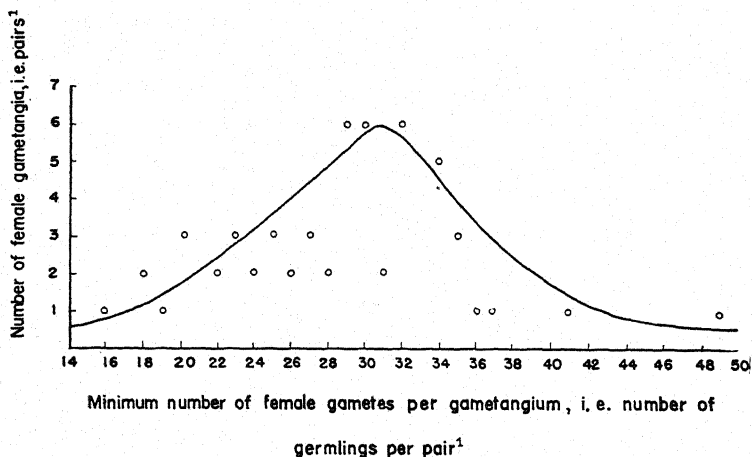
<sup>7</sup> Emerson, 1941. p. 82.



angia studied were grown in water cultures, baited with hemp seed and on maltose-peptone agar plates. The resistant sporangia were dried for different periods of time, introduced into glass-distilled water and then brought under observation under supported cover slips.

#### RESISTANT SPORANGIA INCAPABLE OF ZOÖSPOROGENESIS

When dried, resistant sporangia from either water or agar cultures are placed in distilled water or in a maltose-peptone solution and then are brought under observation, it is relatively



<sup>1</sup> Couplets of 1 male and 1 female gametangium

FIG. 1.

easy to determine which of the resistant sporangia are incapable of zoösporigenesis because these resistant sporangia become filled with several relatively large spheres which are sometimes of nearly uniform size (FIG. 2, *a*), at other times are of noticeably different size (FIG. 2, *b*). These spheres are apparently formed by the enlargement and coalescence of "lipoid granules."<sup>8</sup> The "lipoid granule" is a normal constituent of the cytoplasm of *Allomyces arbusculus*. In living, healthy cytoplasm the "granules" are small. When the cytoplasm in a hypha, gametangium, or spor-

<sup>8</sup> This is Guilliermond's term (1920), (1922), (1922). Actually they are more like "droplets" in shape and consistency.

angium breaks down or when a gamete or zoöspore dies, the first morphological manifestation of death is a marked increase in the size of the "granules" (Hatch, 1935). From these observations it seems very likely that resistant sporangia in which these enlarged spheres appear could not be brought to dehiscence under any condition, for they are, in all probability, no longer alive.

#### THE PROCESS OF ZOÖSPOROGENESIS IN RESISTANT SPORANGIA

Resistant sporangia capable of zoösporogenesis undergo a series of metamorphoses that parallel those experienced in gametogenesis (Hatch, 1933, 1935). When resistant sporangia are ready to undergo zoösporogenesis, a change in their appearance—the initial change—may be expected in approximately 10 minutes after they have been introduced into distilled water or maltose-peptone solutions. At this time the resistant sporangia take on a granular appearance. After approximately 2 hours this stage gives way to a phase in which the peripheral cytoplasm of the resistant sporangia becomes studded with "circles." In another  $30 \pm$  minutes these "circles" disappear and the resistant sporangia again become granular in appearance. This stage lasts only for a few minutes before the outlines of the R. S. zoöspores<sup>9</sup> become apparent. Dehiscence, meaning the swelling of the R. S. zoöspores and the cracking of the resistant sporangium wall, takes approximately 60 minutes. It has become a convention to speak of these stages as the *granular*, *zoöspore origin*, *disappearance*, *cleavage*, and *dehiscence* stages respectively.

An aspect of zoösporogenesis in resistant sporangia to which attention should be called is the fact that the process itself is not ordinarily initiated in the culture where the resistant sporangia are formed, or if initiated, it certainly does not proceed beyond the *pre-granular* stage. The word "ordinarily," last sentence, is used advisedly, because under certain conditions resistant sporangia do undergo zoösporogenesis in water cultures. Gametogenesis and zoösporogenesis in zoösporangia, on the other hand, are characteristically carried to completion in water cultures. In agar cultures they are halted in the *gamete* or *zoöspore origin* stage. In water cultures where conditions are such as to discourage or

<sup>9</sup> Zoöspores from resistant sporangia, Emerson's abbreviation.

prohibit dehiscence these processes are likewise brought to at least a temporary stop. In these instances where gametogenesis and zoösporogenesis in zoösporangia are halted, it is well to observe that the processes in question always reach the *origin* stage in their development—always complete their nuclear divisions. A second peculiarity of zoösporogenesis in resistant sporangia that will stand emphasis is the fact that it does not occur ordinarily until the resistant sporangia have been dried.

The fact that zoösporogenesis in resistant sporangia does not ordinarily occur until resistant sporangia have been dried and/or placed in fresh water or nutrient solutions makes it possible for the experimenter to isolate this process in point of time and place and so control the conditions under which it is initiated and under which it proceeds. Since meiosis regularly occurs during this process, we have in the resistant sporangia of *Allomyces* structures in which the phenomenon of meiosis can be most advantageously studied.

GRANULAR STAGE (FIG. 2:  $c_1$ ,  $c_2$ ,  $c_3$ ,  $c_4$ )

While resistant sporangia in the *granular* stage appear superficially to be granular throughout, closer observation shows that the cytoplasm is very vacuolate, that the granules ("lipoid granules") are dispersed over the faces of intervacuolar films. Actually, the cytoplasm of resistant sporangia is so vacuolate that the nuclei or the nuclear spindles, as the case may be, are often elongated, twisted or otherwise distorted.

The *granular* phase is the longest and the most critical phase of zoösporogenesis. During this phase the "lipoid granules" decrease in size. Initially there may be no more than 5–12 nuclei in resistant sporangia, the number found in the hyphal tips when the resistant sporangia are formed. Ultimately the number may become as great as  $88 \pm$  to  $136 \pm$  or even perhaps  $164 \pm$ . The nuclei are at first large, at least as large as the nuclei found in the hyphae. After the *granular* stage has run its course, the nuclei become very small. It is obvious that these nuclei have undergone many mitoses and, probably, meiosis as well. In the granular stage the vacuoles also experience a gradual change, consolidating toward the center of the resistant sporangia, forcing

the nuclei to the periphery. It is this change which brings about the altered appearance of the sporangia which is conventionally described as the *zoöspore origin* stage.

#### ZOÖSPORE ORIGIN STAGE (FIG. 2: *d, e*)

The so-called *origins* are the nuclei. Since the nuclei at this stage are forced against the wall and since they attract to their respective surfaces the very numerous "lipoid granules," they look like circles outlined by dots. Since the full nuclear complements of resistant sporangia are achieved by this time, the number of nuclei produced is the same as the number of R. S. zoöspores that will ultimately be formed. In this sense, but in this sense only, can these nuclei be considered zoöspore origins. The number of nuclei or origins in resistant sporangia is large.

#### DISAPPEARANCE AND CLEAVAGE STAGES (FIG. 2, *f*)

After approximately 30 minutes in the *zoöspore origin* stage, the cytoplasm becomes organized about the nuclei, cleavage furrows come in and the R. S. zoöspores are cut out. The number of R. S. zoöspores formed is, of course, the same as the number of nuclei or *origins* formed at the onset of the *zoöspore origin* stage. The swelling of resistant sporangia, so characteristic of the process of zoösporogenesis in resistant sporangia, does not begin until the R. S. zoöspores have been completely delimited.

#### DEHISCENCE (FIG. 2, *g*)

The process of dehiscence has been described by both Emerson (1941) and Sörgel (1937), and while Emerson describes the process under the name "germination," his interpretation and the writer's are the same. Dehiscence involves the swelling that cracks the thick middle wall as well as the cracking itself. According to Emerson, the process of dehiscence (*i.e.* the whole process) takes approximately 60 minutes from the cracking of the thick middle wall to the discharge of the first R. S. zoöspore.

#### THE R. S. ZOÖSPORE (FIG. 2, *h*)

The structure of an R. S. zoöspore is not unlike that of a gamete, in that it normally has a single cilium, a single nucleus, a nuclear

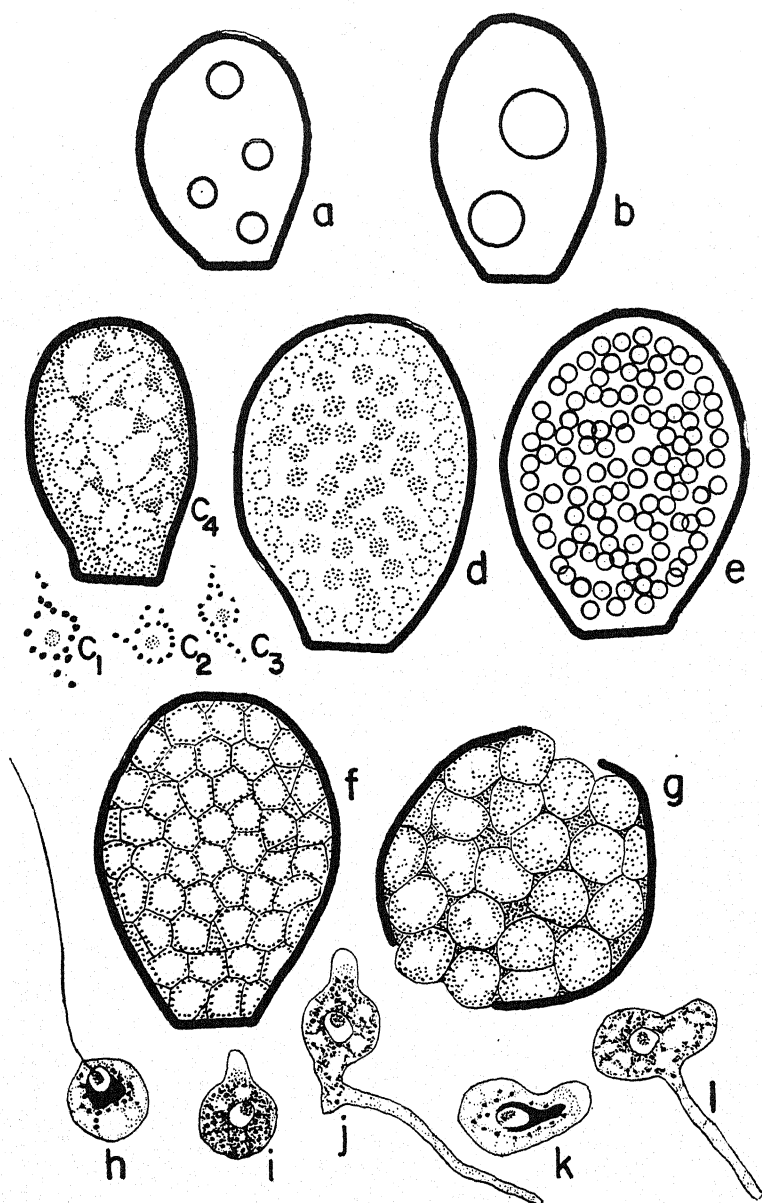


FIG. 2. Zoösporogenesis in resistant sporangia. See page 663, explanation of figures.

cap, and dispersed "lipoid granules." The cilium is inserted on the R. S. zoöspore membrane and has a rhizoplast extension which ultimately connects with the nucleolus in precisely the same way as it does in the gamete. The nuclear cap seems small but whether it is proportionately smaller than the same structure in the gamete is not easily determined. The R. S. zoöspore's quota of "lipoid granules" is apparently not as great as that of the gamete.

The swarming habits of R. S. zoöspores vary. Some swim for but a minute or two; others for 15 to 20 minutes; while still others alternately swim and crawl for better than two hours. These differences in swarming habit are found even among the products of a single resistant sporangium.

The history of the R. S. zoöspores that swim for a few minutes is shown in figure 2; *k, l*. These R. S. zoöspores, always a relatively small number, become amoeboid soon after their discharge from the resistant sporangia. They often persist in their amoeboid movements up to the very moment of their germination. In fact, encystment and germination appear to be almost simultaneous because the R. S. zoöspores do not always round up before pushing out their germ tubes.

Those R. S. zoöspores that swarm for 15 to 20 minutes characteristically round up in the process of encystment, but even among these R. S. zoöspores encystment precedes the extension of the germ tube by only a matter of minutes. In R. S. zoöspores of this type (FIG. 2: *i, j*) the germ tubes are often clearly visible 12 minutes after encystment.

Those R. S. zoöspores that swim for more than two hours do not swim about for the whole period but lapse into several prolonged periods of amoeboid activity. These R. S. zoöspores have never been observed to germinate.

When R. S. zoöspores encyst, the movement of the cilium stops instantly—the cilium is apparently cast. The process of R. S. zoöspore germination is not unlike that of the zygote, in that the nuclear cap becomes disassociated prior to or just after the development of the germ tube.

The time table for zoösporogenesis is apparently very variable. In some instances and under certain conditions dehiscence is

accomplished in  $2\frac{1}{2}$  hours after the resistant sporangia are introduced into distilled water or maltose-peptone solutions. In other instances and under other conditions dehiscence has not been observed before 4, 8, 12 and even 20 hours.

#### NUMBER OF ZOÖSPORES IN RESISTANT SPORANGIA

The number of R. S. zoöspores that will be produced in a given resistant sporangium is most easily determined by counting the nuclei in the *zoöspore origin* stage (FIG. 2: d, e). After the R. S. zoöspores have been delimited it is more difficult, if not impossible, to count them, and at any time previous to the *zoöspore origin* stage any count of nuclei would be without meaning in determining R. S. zoöspore number because the nuclei would not as yet have completed their nuclear divisions. In the *zoöspore origin* stage the nuclei can be counted with accuracy because of their peripheral position and because they are outlined by lipid granules.

The number of nuclei formed in resistant sporangia is relatively large. Kniep (1930) observed that resistant sporangia ultimately produced a great many nuclei, but his observation does not prepare one for counts of  $88 \pm$  to  $136 \pm$ , let alone counts of  $164 \pm$ .

Counts made upon female gametangia in the same stage of division, namely, the *gamete origin* stage, are known to possess from 12 to 36 nuclei (Hatch, 1935). While no higher counts have been made directly on female gametangia, we have reason to believe that some large female gametangia may possess as many as 41 and possibly as many as 49 gametes.

A comparison of resistant sporangia and female gametangia as regards their nuclear complements can not be made without taking into account the relative volumes of the two structures. To this end a single resistant sporangium in the *zoöspore origin* stage and a single female gametangium in the *gamete origin* stage were compared. The volumes and the nuclear counts of these two structures are recorded in table I.

The volumes given in the table were arrived at by using the formula  $\frac{4}{3} xy^2\pi$ , in which "x" equals the long radius and "y," the short. In this, the formula for the volume of a prolate

spheroid, a portion at the base of both the resistant sporangium and female gametangium is not calculated. The volumes then do not represent the actual volumes of the two structures, but something less. It is for this reason that the plus sign (+) appears after the figures. While the volumes determined through the use of this formula do not represent the actual volumes of the structures in question, they do indicate *relative volumes*. Since the relative volumes are all that are needed in this analysis, the formula seems adequate, if not entirely satisfactory. Calculating the volumes of these structures as though they were spheres would, it would seem, be even less satisfactory. Turning now to table I we find that the volume of the resistant sporangium was  $11,750 + \text{cu. } \mu$ , its nuclear number  $104 \pm$ . The volume of the female gametangium was  $21,750 + \text{cu. } \mu$ , its nuclear number 36.

While the volume of the resistant sporangium described in table I is considerably smaller than the volume of the female gametangium with which it is compared, it must not be concluded that resistant sporangia are regularly smaller than female gametangia. As a matter of fact, when large enough samples are studied, resistant sporangia and female gametangia appear to have approximately the same volume. The volume of a resistant sporangium of mean size, using Emerson's measurement but correcting for the thickness of the middle wall, is  $22,430 \text{ cu. } \mu$ . No statistical study has been made of female gametangia but if we consider the figures on the minimum number of female gametes per gametangium described in the paragraph below and shown in figure 1, we find that a gametangium possessing 36 gametes is only  $25 \pm$  per cent above the mean. Since the figures referred to above deal with the minimum number of female gametes per gametangium, it is probable that a female gametangium with 36 gametes is even nearer the mean. Lacking a complete statistical study of female gametangia, it is probably reasonable to conclude that the volume of the female gametangium considered in table I, namely  $21,750 \text{ cu. } \mu$ , is near the mean for female gametes and can be compared with the mean volume for resistant sporangia, namely  $22,430 \text{ cu. } \mu$ .

The number of nuclei counted in the resistant sporangium described in table I was  $104 \pm$ . The number of nuclei in the



TABLE I  
COMPARATIVE FIGURES ON A RESISTANT SPORANGIUM AND A  
FEMALE GAMETANGIUM

	Volume	Origin stage	Cleavage stage
		Number of <i>origins</i> or nuclei	Volume of zoöspores and gametes
Resistant sporangium. . . . .	11,750+cu. $\mu^*$	104 $\pm$	113+cu. $\mu^\dagger$ (zoöspores)
		$\updownarrow$	$\updownarrow$
Female gametangium. . . . .	21,750+cu. $\mu^\dagger$	36	604+cu. $\mu^\S$ (gametes)

\* Measurements from inner face of the thick wall =  $36.4 \times 24.8 \mu$ .

† Measurements =  $34.9 \times 34.4 \mu$ .

‡ Volumes estimated by dividing vol. resistant sporangium by no. of origins.

§ Volumes estimated by dividing vol. female gametangium by no. of origins.

resistant sporangia found on the plant with this sporangium varied between  $88 \pm$  and  $136 \pm$ . In addition to these studies counts were made upon the products of single resistant sporangia. The number of plants formed from the R. S. zoöspores produced by individual resistant sporangia varied between 109+ and  $164 \pm$ .

From the evidence of nuclear counts made in the *zoöspore origin* stage and from single resistant sporangia isolations, we can conclude that  $104 \pm$  is less than the mean for the number of nuclei in resistant sporangia.

The number of nuclei counted in the female gametangium described in table I was 36. In earlier counts by the writer (Hatch, 1935), on a small sample, the number varied between 12 and 36. In a series of experiments undertaken in connection with quite another problem, 63 pairs of co-joined male and female gametangia were isolated. From 55 of these pairs numerous asexual germlings developed. Since the female gametangia involved in these isolations may have possessed more gametes than is to be deduced from the number of germlings produced by each isolated pair, the number quoted in each case represents the minimum number of gametes. The mean number of female gametes per gametangium, *i.e.*, the number of germlings per pair, and the statistical distribution of these numbers is shown in

TABLE II  
COMPARATIVE VOLUMES FOR R. S. ZOÖSPORES AND FEMALE GAMETES

	At cleavage	At swarming
R. S. Zoöspores.....	110+--134+ cu. $\mu^*$	$\leftrightarrow$ 223-606 cu. $\mu^\dagger$
Female gametes.....	288-675 cu. $\mu^\dagger$	(288-675 cu. $\mu$ )§

\* Vols. estimated by dividing vols. resistant sporangia by no. of their origins.

† Vols. essentially same as for swarming gametes. See §.

‡ Vols. computed from Emerson's measurements. Mean diam. = 7.5-105  $\mu$ .

§ Vols. computed from Emerson's measurements. Mean diam. = 8.2-10.8  $\mu$ .

figure 1. The minimum number of female gametes per gametangium, *i.e.*, the mean number of germlings per pair, was 28.7—the minimum 16, the maximum 49. From this we can conclude that 36 is above the mean number for female gametangia.

In sum, when all nuclear division has ceased in resistant sporangia, the number of nuclei or *zoöspore origins* is approximately four times as great as the number of nuclei or *gamete origins* found in female gametangia, structures of approximately the same volume. The actual counts were  $88 \pm$  to  $136 \pm$  for resistant sporangia, 12 to 36 for female gametangia.

#### VOLUME OF ZOÖSPORES IN RESISTANT SPORANGIA

The relative volumes of R. S. zoöspores and female gametes are shown in table I, last column, and in table II.

In table I, last column, the volume of the zoöspores in a single resistant sporangium are compared with the volume of the gametes in a single female gametangium. The volume of the R. S. zoöspores was  $113 +$  cu.  $\mu$ ,\* that of the female gametes  $604 +$  cu.  $\mu$ .\*

In table II the volumes of R. S. zoöspores and female gametes are compared. From a study of the table it is apparent that the volume ( $110 +^* - 134 +^*$  cu.  $\mu$ ) of R. S. zoöspores at cleavage is ap-

\* These volumes are greater than stated because they have been calculated from the volumes of resistant sporangia and female gametangia which were greater than could be computed.

proximately one-fourth as great as the volume (288–675 cu.  $\mu$ ) of female gametes at cleavage; is approximately one-fourth as great as the volume (223–606 cu.  $\mu$ ) of swarming R. S. zoöspores.

The relative volumes of the nuclei of R. S. zoöspores and female gametes are shown in table III. From a study of the table it is apparent that the nuclei of R. S. zoöspores and female gametes compare as do the zoöspores and gametes themselves. The volume (2.7–4.7 cu.  $\mu$ ) of the nuclei of the R. S. zoöspores at cleavage is approximately one-fourth as great as the volume (9.0–25.3 cu.  $\mu$ ) of the nuclei of female gametes at cleavage; is approximately one-fourth as great as the volume (10.8–17.3 cu.  $\mu$ ) of the nuclei of swarming R. S. zoöspores.

TABLE III  
COMPARATIVE VOLUMES FOR THE NUCLEI OF R. S. ZOÖSPORES AND  
FEMALE GAMETES

	At cleavage		At swarming
R. S. zoöspore, nuclei. . . . .	2.7–4.7 cu. $\mu$ *	↔	10.8–17.3 cu. $\mu$ †
	↑		
Female gamete, nuclei. . . . .	9.0–25.3 cu. $\mu$ †		(9.0–25.3 cu. $\mu$ )§

\* Volumes computed from mean diameters of 1.7–2.0  $\mu$ .

† Volumes essentially same as for swarming gametes. See §.

‡ Volumes computed from mean diameters of 2.7–3.2  $\mu$ .

§ Volumes computed from mean diameters of 2.9–3.6  $\mu$ .

#### SUMMARY

(1) Zoösporogenesis in resistant sporangia is not normally initiated until the resistant sporangia have been dried and/or placed in fresh water or nutrient solution.

(2) The *number* of R. S. zoöspores per resistant sporangium is approximately 4 times as great as the number of female gametes produced in the female gametangium, a structure of approximately the same volume.

(3) The *volume* of R. S. zoöspores at cleavage is approximately one-fourth as great as the volume of female gametes at cleavage.

(4) The *volume* of R. S. zoöspores at cleavage is approximately one-fourth as great as their volume when swarming.

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## EXPLANATION OF FIGURES

FIG. 1. Minimum number of female gametes per gametangium.

FIG. 2. Zoösporogenesis. (a-g.) Resistant sporangia. The thin outer and inner walls are not shown. The thick middle wall is drawn in median optical section; its sculpturing is not shown. *a* and *b*. Resistant sporangia incapable of zoösporogenesis. Note characteristic spheres probably enlarged "lipoid granules." *c*. Granular stage: *c*<sub>1</sub>, *c*<sub>2</sub>, *c*<sub>3</sub>, *c*<sub>4</sub>, stages showing the progressive decrease in the size of the nuclei and "lipoid granules." (Lipoid granules outline nuclei.) In the resistant sporangium two nuclei are shown in outline, 7 as local concentrations of "lipoid granules." *d*. Zoöspore origin stage: Nuclei (*origins*) at a median focus are outlined by "lipoid granules." Those in the face toward the observer are studded with "lipoid granules." Total number nuclei (*origins*) = 88; 28 nuclei on the face away from the observer are not drawn. *e*. Full quota nuclei (*origins*) for a resistant sporangium. Total number = 104. *f*. Cleavage stage. *g*. Dehiscence. *a-g* =  $\times 1055$ . *h*. R. S. zoöspore, motile. Note vacuolate cytoplasm, small number of "lipoid granules," nuclear cap, nucleus, cilium with rhizoplast. *i* and *j*. Germinated, R. S. zoöspores. *k*. Amoeboid R. S. zoöspore. *l*. Germinated, R. S. zoöspore. A few R. S. zoöspores germinate without rounding up. *h-l* =  $\times 1521$ .

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- ROTH, LEWIS F(RANKLIN), Instructor of Plant Pathology and Botany, *Department of Botany, Oregon State College, Corvallis, Ore.* (Soil fungi.)
- ROUTIEN, JOHN B., *Montezuma, Ind.* (Taxonomic mycology; mycorrhizae.) Corporal, Medical Department, A. U. S.
- RUDOLPH, DR. BERT A., Associate Plant Pathologist in Charge, University of California Deciduous Fruit Station, *Route 1, Box 92, San Jose, Calif.* (Plant pathology.)
- RUEHLE, DR. GEO(RGE) D(EWEY), Plant Pathologist and Vice-Director-in-Charge, *Subtropical Experiment Station, Homestead, Fla.* (Plant pathology.)
- RUSDEN, DR. PHILIP L., *206 Federal Building, Central Sq., Cambridge, Mass.* (Cytology; Phycomycetes; Gasteromycetes.)
- RYAN, SISTER MARY HILAIRE, O.P., Ph.D., Associate Professor of Biology, *Rosary College, River Forest, Ill.* (Fungi.)
- SANTACROCE, NUNZIO GEORGE, *Forest Home Drive, Ithaca, N. Y.* Private, Service Bty.
- SAVILLE, D(UGLAS) B. O., Junior Plant Pathologist, *Division of Botany and Plant Pathology, Central Experimental Farm, Ottawa, Ontario, Canada.* (Taxonomic plant pathology; cytology of fungi.)
- SCHAFER, MAJOR NATHAN, *La Garde General Hospital, New Orleans, La.* (Systemic fungus infection.) Medical Corps.
- SCHNEIDERMAN, BENJ., Chief Chemist, Biological Group, *Centro Research Laboratories, Inc., 855 Meeker Ave., Brooklyn 22, N. Y.*
- SCULLY, DR. FRANCIS J., *904 Medical Arts Building, Hot Springs, Ark.* (Amateur interest in taxonomic botany.)
- SEAVER, MISS BERNICE, *Marion, N. C.*
- SEAVER, DR. FRED J(AV), Head Curator, *The New York Botanical Garden, Bronx Park, N. Y.* (Pezizales; taxonomy.)
- SEELER, EDGAR V., Honorary Research Associate in Mycology, Farlow Herbarium, *20 Divinity Ave., Cambridge, Mass.*
- SHANOR, DR. LELAND, Research Mycologist, National Defense Research Committee, Tropical Deterioration Project, *George Washington University, 720 20th St., N.W., Washington 6, D. C.* On leave of absence from the University of Illinois. (Aquatic Phycomycetes; plant disease fungi, fungal deterioration of textiles and cordage.)
- SHEAR, DR. C(ORNELIUS) L(OTT), Collaborator, U. S. Department of Agriculture, *Plant Industry Station, Beltsville, Md.* (Taxonomy of Pyrenomycetes.)

- SHERBAKOFF, DR. C(ONSTANTINE) D., Plant Pathologist, *Agricultural Experiment Station, University of Tennessee, Knoxville, Tenn.* (Diseases of wheat, cotton, red clover, tomatoes, strawberries; the genus *Fusarium*.)
- SHIMP, MRS. H(ELENE NUSSLE), 3943 St. Clair Ave., Detroit 14, Mich. (Edible fungi.)
- SHOUP, DR. C(HARLES) S(AMUEL), Associate Professor of Biology, Box 77, *Department of Biology, Vanderbilt University, Nashville, Tenn.* (Respiration; oxidations.)
- SINDEN, DR. JAMES W., Associate Professor, *Department of Botany, Pennsylvania State College, State College, Pa.* (Commercial mushrooms; physiology of fungi.)
- SINGER, DR. ROLF, Research Associate, Harvard University, Farlow Herbarium, 20 Divinity Ave., Cambridge, Mass. (Taxonomy of the Agaricales.)
- SLEETH, DR. BAILEY, Plant Pathologist, Bureau of Plant Industry, P. O. Box 1708, Salinas, Calif. (Forest and Guayule pathology.)
- SLIPP, ALBERT W(ISWELL), Research Associate, *School of Forestry, University of Idaho, Moscow, Idaho.* (Ecology of forest fungi.)
- SMART, DR. ROBERT F(ORTE), Professor, *Department of Biology, Richmond, Va.* (Physiology of Myxomycetes; cytology of Ascomycetes.)
- SMITH, LT. ALBERT G(REGORY), *Materials Laboratory, Engineering Division, Wright Field, Dayton, Ohio.* Army Air Corps.
- SMITH, DR. ALEXANDER H., Associate Curator of Fungi, Herbarium, *Museums Building, University of Michigan, Ann Arbor, Mich.* (Cytology and taxonomy of Agaricaceae.)
- SNELL, DR. WALTER H(ENRY), Stephen T. Olney Professor of Botany and Chairman, *Botany Department, Brown University, Providence 12, R. I.* (Taxonomy of Boletaceae and pileate Hydnaceae.)
- SNYDER, DR. WILLIAM C., Associate Professor of Plant Pathology, 107 Hilgard Hall, *University of California, Berkeley, Calif.* (Taxonomy of *Fusarium*; vegetable pathology.)
- SOLHEIM, DR. W(ILHELM) G(ERHARD), Professor of Botany and Head, *Department of Botany, University of Wyoming, Laramie, Wyo.* (Rocky Mountain fungi; Hyphomycetes.)
- SPARROW, DR. FREDERICK K(ROEBER), JR., *Department of Botany, University of Michigan, Ann Arbor, Mich.* (Comparative morphology; biology; distribution of aquatic Phycomycetes.)
- SPRAGUE, DR. RODERICK, Plant Pathologist, U. S. Department of Agriculture, *Northern Great Plains Field Station, Mandan, N. D.* (Fungi Imperfecti on Gramineae.)
- SPRINGER, DR. MARTHA E(DITH), Instructor of Botany, *Indiana University, Bloomington, Ind.* (Aquatic Phycomycetes.)
- STAKMAN, DR. E(LVIN) C., Professor and Chief of Division of Plant Pathology and Botany, University of Minnesota, and Agent, U. S. Department of Agriculture, *University Farm, St. Paul, Minn.* (Plant pathology; mycology.)
- STEVENS, NEIL E(VERETT), *Department of Botany, University of Illinois, Urbana, Ill.*

- STEVENS, DR. RUSSELL B(RADFORD), Assistant Professor of Biology, *Department of Biology, Birmingham-Southern College, Birmingham, Ala.* On leave of absence. (Mycology, lichens.) Lieutenant, Sanitary Corps.
- STEVENSON, JOHN A(LBERT), Senior Mycologist in Charge, Mycological Collections, Bureau of Plant Industry; *4113 Emery Pl. N.W., Washington 16, D. C.* (Taxonomy.)
- STIFLER, MRS. CLOYD BURNLEY (Mrs. James M.), *315 16th St., Bradenton, Fla.*
- STOUFFER, DAVID J(AMES), Forest Ranger, *Corona, N. M.*
- STRONG, MRS. MIRIAM C., Research Assistant in Plant Pathology, Department of Botany, Michigan State College; *1213 N. Walnut St., Lansing, Mich.* (Fusaria and tomato diseases.)
- STUNTZ, D(ANIEL) E(LLIOT), Instructor in Botany, *Department of Botany, University of Washington, Seattle, Wash.* (Agaricaceae.)
- SUMSTINE, DR. DAVID R., Honorary Associate in Botany, Carnegie Museum; *King Edward Apt., Pittsburgh 13, Pa.* (Taxonomy; Hyphomycetes.)
- SWARTZ, DR. DELBERT, Associate Professor of Botany, University of Arkansas, *Box 93, University Station, Fayetteville, Ark.* (Comparative morphology of Lycopodiaceae.)
- SWARTZ, DR. JACOB HYAMS, Assistant Professor of Dermatology, Harvard Medical School, *371 Commonwealth Ave., Boston, Mass.* (Medical mycology and dermatology.)
- SWEET, DR. HERMAN R., Assistant Professor in Biology, Tufts College; *155 Lincoln Road, Medford 55, Mass.*
- TEHON, DR. LEO R(OY), Botanist and Head of Section of Applied Botany and Plant Pathology, Illinois State Natural History Survey, *337 Natural Resources Building, Urbana, Ill.* (Taxonomy; Hypodermataceae; fungus flora of Illinois.)
- TERVET, IAN W., Department of Plant Pathology, *University Farm, St. Paul, Minn.*
- TETER, HAROLD E., Teacher of Biology, Mackenzie High School, Detroit; *Route 1, Box 66, Northville, Mich.*
- THIRUMALACHAR, M(ANDAYAM) J(EERSANNIDHI), Lecturer in Botany, Central College, Bangalore, *20th. V Main Road, Malleswaram, Bangalore, India.*
- THOM, DR. CHARLES, U. S. Department of Agriculture. Retired. *Port Jefferson, L. I., N. Y.* (Taxonomy and physiology of saprophytic molds.)
- THOMPSON, DR. GEORGE E(DWARD), Associate Professor in Plant Pathology, *College of Agriculture, University of Georgia, Athens, Ga.* (Forest pathology; general mycology.)
- THURSTON, DR. H. W., Department of Botany, *Pennsylvania State College, State College, Pa.*
- TIFFNEY, DR. WESLEY N., *American International College, Springfield, Mass.* (Phycomycetes.)
- TORREY, G(EORGE) SAFFORD, Professor of Botany, University of Connecticut; *R. F. D. 2, Storrs, Conn.* (Intestinal fungi of Arthropods.)
- TUCKER, DR. C(LARENCE) M(ITCHELL), Chairman, Department of Botany, University of Missouri, *100 Lefevre Hall, Columbia, Mo.* (Phycomycetes; plant pathology.)

- TULLIS, DR. EDGAR C., Pathologist, U. S. Department of Agriculture, Cereal Crops and Diseases, *P. O. Box 2967, Beaumont, Texas.* (Rice disease.)
- UMANZIO, CARL B(EEMAN), Assistant Professor of Bacteriology, *77 Ramshead Road, Medford, Mass.* (Medical mycology.)
- VANTERPOOL, T(HOMAS) C(LIFFORD), Professor of Plant Pathology, *Department of Biology, University of Saskatchewan, Saskatoon, Saskatchewan, Canada.* (Root rots of cereals, particularly those caused by *Pythium*; flax diseases.)
- VERMILLION, M(ONROE) T(HOMAS), Instructor in Botany, Ohio University; *Earick Road, R. D. 3, Athens, Ohio.*
- WAKSMAN, DR. SELMAN A., Professor and Head, Department of Soil Microbiology, *New Jersey Agricultural Experiment Station, Rutgers University, New Brunswick, N. J.* (Soil mycology; Actinomycetes; physiology of fungi; production of antibiotic substances by microorganisms.)
- WALKER, DR. A(NSON) R(OBERTSON), Professor of Plant Pathology, *Department of Botany, University of Western Ontario, London, Ontario, Canada.* (Comparative morphology.)
- WALKER, DR. LEVA B(ELLE), Associate Professor of Botany, *University of Nebraska, Lincoln 8, Nebr.* (Morphology.)
- WALTERS, MAURICE B., *14556 Superior Road, Cleveland Heights, Ohio.*
- WATERMAN, DR. ALMA M(AY), Assistant Pathologist, U. S. Department of Agriculture, *360 Prospect St., New Haven, Conn.* (Diseases of shade and ornamental trees.)
- WATERSTON, J. M., Plant Pathologist, *Department of Agriculture, Agricultural Station, Paget East, Bermuda.* (Mycology; plant pathology.)
- WEBER, DR. GEORGE F(REDERICK), Professor of Plant Pathology, *University of Florida, Gainesville, Fla.* (Parasitic fungi; taxonomy.)
- WEHMEYER, DR. LEWIS E(DGAR), Associate Professor, Department of Botany, University of Michigan; *381 Orchard Hill Dr., Ann Arbor, Mich.* (Pyrenomycetes.)
- WEIDMAN, DR. FRED(ERICK) D(EFOREST), *Medical Laboratories, University of Pennsylvania, 36th St. and Hamilton Walk, Philadelphia, Pa.* (Medical mycology and dermatology.)
- WELCH, DR. DONALD STUART, Professor in Plant Pathology, *New York State College of Agriculture, Cornell University, Ithaca, N. Y.* (Taxonomy of Pyrenomycetes and Polyporaceae; forest pathology.)
- WELLMAN, DR. F(REDERICK) L(OVEJOY), *10108 Pierce Drive, Silver Spring, Md.* (Physiology; morphology; variability; parasitism.)
- WERNHAM, DR. CLIF(FORD) C(HARLES), *Department of Botany, Pennsylvania State College, State College, Pa.* (Genetics and physiology.)
- WEST, ERDMAN, Mycologist in charge of Herbarium, *Florida Agricultural Experiment Station, Gainesville, Fla.* (Taxonomy of Florida fungi; timber decaying fungi; Myxomycetes; rusts; *Sclerotium Rolfsii*; Florida plants.)
- \*\*WESTON, DR. WILLIAM H., JR., Professor of Cryptogamic Botany, Harvard University, *Biological Laboratories, 16 Divinity Ave., Cambridge 38, Mass.* (Phycomycetes; scientific interest and economic importance of fungi.)

- WHELDEN, DR. R(OY) M(AXFELD), Harvard University, *Biological Laboratories, Divinity Ave., Cambridge, Mass.* (Cytology; radiation effects.)
- WHETZEL, PROF. H(ERBERT) H(ICE), Professor of Plant Pathology, *Cornell University, Plant Science Building, Ithaca, N. Y.* (Taxonomy and morphology of Sclerotiniaceae.)
- WHIFFEN, ALMA J., *Research Laboratories, Upjohn Company, Kalamazoo, Mich.* (Phycomycetes; penicillin.)
- WHITE, DR. W. LAWRENCE, Research Associate in Chemical Warfare, Chemical Warfare Service Development Laboratory, Massachusetts Institute of Technology; *Farlow Herbarium, Harvard University, Cambridge, Mass.* (Mold-proofing military equipment for use in tropics.)
- WOLF, DR. FREDERICK A., Professor of Botany, *Duke University, Durham, N. C.* (Morphology; taxonomy.)
- WOLF, DR. FRED(ERICK) T(AYLOR), Assistant Professor of Botany, *Department of Biology, Vanderbilt University, Nashville, Tenn.* On leave of absence. (Phycomycetes.)
- WOLFF, MISS EMILY T(OWER), Research Botanist, *American Cyanamid Co., Stamford, Conn.* (Commercial problems involving plant materials, referred to microscopy laboratory.)
- WOOLLIAMS, G(EORGE) E(WART), Agricultural Scientist, Dominion of Canada, Department of Agriculture, *Dominion Laboratory of Plant Pathology, Summerland, British Columbia, Canada.* (Taxonomy; pathology.)
- WRIGHT, C(HARLES) M(ILTON), Research Assistant, *Department of Plant Pathology, Cornell University, Ithaca, N. Y.*
- YARWOOD, DR. CECIL E(DMUND), Assistant Professor of Plant Pathology, *Division of Plant Pathology, University of California, Berkeley, Calif.* (Powdery mildews; downy mildews.)
- YAW, MISS CATHERINE EMILY, Research Mycologist, Parke-Davis and Co.; *427 E. Grand Blvd., Detroit, Mich.*
- YORK, HARLAN H(ARVEY), Professor of Botany, *Department of Botany, University of Pennsylvania, Philadelphia, Pa.* (Forest pathology.)
- ZELLER, DR. S(ANFORD) M(YRON), Plant Pathologist, *Oregon Agricultural Experiment Station, Oregon State College, Corvallis, Ore.* (Parasitic fungi and Gasteromycetes.)
- ZUNDEL, DR. GEORGE L(ORENZO) INGRAM, Assistant Professor of Plant Pathology, Extension Division, *203 Botany Building, Pennsylvania State College, State College, Pa.* (Ustilaginales.)

## MEMBERS DECEASED

1943-1944

BULLER, ARTHUR HENRY REGINALD  
 BURNHAM, STEWARD HENRY  
 GOLDSMITH, GLENN WARREN  
 HENRICI, ARTHUR TRAUTWEIN  
 HORNE, WILLIAM TITUS

## CONSTITUTION AND BY-LAWS

## CONSTITUTION

*Art. 1. Name.* The Society shall be known as the Mycological Society of America.

*Art. 2. Membership.*

(1) The Society shall consist of members and may include life members, patrons, honorary members, and corresponding members.

(2) Charter membership in the Society shall consist of the persons who, after the invitation of the Secretary, joined before or during the formal organization of the Society at the Atlantic City meetings in 1932.

*Art. 3. Dues.* The dues for regular members shall be five dollars a year. Any member may become a life member by paying one hundred dollars in one payment, or a patron by paying one thousand dollars, and upon election shall have all the privileges of members. Such funds obtained from life members and patrons shall constitute an endowment fund to be used as may be decided by the Council for the support of mycological publications or projects.

Annual dues of five dollars shall include subscription to the official organ of the Society, and shall be payable in advance on or before December 20. Bills for dues shall be sent to the members in October and it will be necessary to discontinue sending the journal to those whose dues have not been paid by December 20.

*Art. 4. Membership and Election of Members.*

(1) All persons interested in the study of the fungi shall be eligible to membership.

(2) Members may be elected at any regular meeting of the Society or in the interim between meetings may be elected by the Council. Application for membership must be endorsed by at least one member of the Society.

*Art. 5. Officers.* The officers of the Society shall consist of a President, Vice-President, and Secretary-Treasurer, whose duties shall be those usually performed by such officers. The President and Vice-President shall serve for one year and the Secretary-Treasurer for three years (or until their successors are elected). Any vacancies occurring in the interim between elections shall be filled by the Council.

The Council shall consist of the President, Vice-President, Secretary-Treasurer, and four Councilors. The Councilors shall be elected, two each year, to serve a term of two years. Two of the councilors shall be from east of the Mississippi (Minnesota is counted as west of the Mississippi) and two west. An individual may not hold two or more positions on the Council at one time.

The Council shall name a Historian to serve for an indeterminate period of years. It shall be the duty of the Historian to accumulate and preserve facts, papers, photographs, and other materials pertinent to a permanent historical record of the Society. The Historian shall not become a member of the Council by virtue of his office as Historian.



*Art. 6. Editors and Committees.* The editors of the official journal of the Society shall be elected by the Council. The President shall appoint all temporary committees that are to serve during his administration and shall fill all vacancies on standing committees that may occur during his term of office.

*Art. 7. Election of Officers.* The Secretary-Treasurer shall send to each member of the Society in October a ballot for the nomination of officers. If any nominations are lacking, the Council shall have power to make them. The three candidates for each office receiving the highest number of nominating votes shall be placed upon a final ballot to be sent to each member December 1. Should the nominating votes received by a candidate place him among the highest three for more than one office, his name shall appear on the final ballot for only the highest office. The offices rank in the order given in article 5. Votes shall be mailed to the Secretary-Treasurer and counted by the Council. A plurality vote shall elect.

*Art. 8. Meetings.* An annual meeting shall be held at such time and place each year as the Council may select (usually in connection with the A.A.A.S. meetings). An additional meeting for informal discussion and the carrying out of collecting forays shall be held in the summer or autumn at a time to be selected by the Council. Additional meetings, including special or local meetings for the presentation of papers or the carrying out of forays, may be arranged by the Council at its discretion.

*Art. 9. Divisions.* Branch organizations or units within the Society known as Divisions, may be established on a geographical basis provided formal application, setting forth the reasons for the establishment of the Division, is made to the parent Society and approved by it.

*Art. 10. Journal.* The Society shall adopt or establish a journal which shall serve the Society as its official organ primarily for the publication of mycological papers by its members, for the publication of abstracts of the papers delivered at the annual or other meetings, and for the publication of the report of the Auditing Committee or of other reports, announcements, and business of the Society.

*Art. 11. Amendments.* These articles may be amended by a majority vote of the members voting at any regular meeting of the Society, provided that suggested amendments have been brought to the attention of the Council of the Society in time to be sent to all of the members at least one month previous to the meeting.

#### BY-LAWS

*1. Programs.* Programs for annual or other meetings shall be arranged by the Council.

*2. Papers.* Members wishing to present papers at the annual meeting shall submit to the Secretary-Treasurer the substance and conclusions of the papers in a clear and concise abstract of not more than 200 words. These

shall be due on or before November 15, and the Secretary-Treasurer shall be authorized to refuse any received after that date. These abstracts will be edited by the editorial committee of the official journal of the Society for subsequent publication in that organ. Members are urged not to submit titles or abstracts unless they expect to attend the meetings. Except by invitation no member shall offer more than two papers at any one meeting, papers of joint authorship being attributed to the author reading the paper.

3. *Associates.* Students and others not yet members of the Society may attend meetings and forays in the status of Associates, provided they are recommended to the Council by a member of the Society and pay a fee of one dollar. Such Associates, as they are not members, shall not have the privilege of voting and shall not receive the official journal of the Society, but shall enjoy the other privileges of the meetings and forays including the right to present one paper on the program.

4. *Auditing.* At each annual meeting the active President shall appoint an auditing committee to audit the accounts of the Society and of its official publication. An audited statement shall be published in the official organ of the Society.

5. *Use of the Society's name.* Unauthorized use of the name of the Mycological Society of America for advertising or other business ventures is prohibited. The circulation of any unauthorized literature shall be taken as prima facie evidence of the violation of the intent and purpose expressed in this by-law, and the member, after being properly notified, may be expelled from the Society by a majority vote of either the Society at its meetings, or by a majority vote of the Council.

6. *These rules may be amended* by a majority vote of the members voting at any regular meeting of the Society, provided that suggested amendments have been brought to the attention of the Council of the Society in time to be sent to all the members at least one month previous to the meeting.

#### CONTRACT WITH THE NEW YORK BOTANICAL GARDEN

The Mycological Society of America hereby adopts *Mycologia* as its official organ on the following terms:

1. *Mycologia* will continue to be published by the New York Botanical Garden, the editorial policies to be determined by an Editorial Board, consisting of a Managing Editor appointed by the New York Botanical Garden, and five Editors elected by the Mycological Society of America. The term of office of the five elected editors will be five years, except that at the start they will be designated to serve one to five years respectively. One editor will be elected annually, thereafter, to fill the place of each retiring editor.

The six members of the Editorial Board will elect an Editor-in-Chief from among their number. He will be eligible for repeated reelection. Final decision of all questions on editorial policy will be made by him, except that the Managing Editor will have full authority in all matters pertaining to the finances of the journal.

2. All personal subscribers now receiving *Mycologia* may become members of the Mycological Society of America if they so desire. Institutional subscribers to *Mycologia* are not to be regarded as members of the Society.

3. All members of the Mycological Society of America in good standing will receive *Mycologia*. In return the Society will transmit to the New York Botanical Garden, through the Managing Editor, four dollars per year for each such member.

4. The New York Botanical Garden agrees to spend on the publication and distribution of *Mycologia* all funds received from subscriptions, as well as all funds transmitted by the Mycological Society of America. The Garden further agrees to use for these purposes all sums received from the sale of those volumes of the journal which shall be published after this contract is put in force. Earlier volumes remain the property of the New York Botanical Garden. It is understood that the journal will be used by the Garden for exchange purposes as formerly. Should the contract be terminated, it is agreed by the Mycological Society of America that all excess stock of *Mycologia* then on hand will be regarded as the property of the New York Botanical Garden.

5. The New York Botanical Garden reserves the fourth cover page to be used without charge for the advertisement of its publications, including *Mycologia*. The other three cover pages will be used by the Mycological Society of America as it may see fit. All sums collected from paid advertising will be expended on the journal.

6. This contract may be altered at any time by mutual agreement of the New York Botanical Garden and the Mycological Society of America. It may be terminated at the end of any calendar year on six months written notice should it prove unsatisfactory to either party concerned.

7. The contract goes into effect at the beginning of the calendar year 1933.

#### PAST AND PRESENT OFFICERS

PRESIDENT	VICE-PRESIDENT
1932 Wm. H. Weston, Jr.	1933 G. W. Martin
1933 C. L. Shear	1934 B. O. Dodge
1934 H. S. Jackson	1935 John Dearnness
1935 B. O. Dodge	1936 A. H. R. Buller
1936 H. M. Fitzpatrick	1937 L. O. Overholts
1937 John Dearnness	1938 E. B. Mains
1938 L. O. Overholts	1939 D. H. Linder
1939 H. H. Whetzel	1940 E. A. Bessey
1940 D. H. Linder	1941 W. H. Snell
1941 E. A. Bessey	1942 J. N. Couch
1942 E. B. Mains	1943 F. D. Kern
1943 J. N. Couch	1944 N. E. Stevens
1944 G. W. Martin	

## SECRETARY-TREASURER

1932-35 H. M. Fitzpatrick  
 1936-38 D. H. Linder  
 1939-41 J. N. Couch  
 1942-44 G. B. Cummins

## COUNCILORS

1932 N. E. Stevens  
 1932-33 H. S. Jackson  
 1933-34 C. R. Orton  
 1934-35 L. O. Overholts  
 1935-36 C. L. Shear  
 1936-37 B. O. Dodge  
 1937-38 H. M. Fitzpatrick  
 1938-39 W. H. Weston  
 1939-40 L. O. Overholts  
 1940-41 H. H. Whetzel  
 1941-42 F. D. Kern  
 1942-43 D. H. Linder  
 1943 F. D. Heald  
 1943-44 C. W. Dodge  
 1943-44 E. B. Mains  
 1944-45 Lee Bonar  
 1944-45 J. N. Couch

## EDITORIAL BOARD OF MYCOLOGIA

1933- F. J. Seaver, Managing Editor and Editor-in-Chief

1933 H. M. Fitzpatrick	1940-41 F. K. Sparrow
1933-34 J. A. Stevenson	1938-42 S. M. Zeller
1933-35 F. A. Wolf	1939-43 H. S. Jackson
1933-36 G. R. Bisby	1940-44 J. A. Stevenson
1933-37 E. B. Mains	1941-45 J. H. Miller
1934-38 G. W. Martin	1942-46 J. G. Hopkins
1935-39 J. A. Stevenson	1943-47 A. H. Smith
1936-40 F. A. Wolf	1944-48 W. W. Ray
1937-41 J. N. Couch (resigned Dec. 1939)	

## MEMBERSHIP COMMITTEE

F. J. Seaver, Chairman	Erdman West
S. M. Zeller	E. B. Mains

## NOMENCLATURE COMMITTEE

D. P. Rogers, Chairman	F. J. Seaver
H. M. Fitzpatrick	A. H. Smith
H. S. Jackson	F. K. Sparrow
E. B. Mains	

## COMMITTEE ON MEDICAL MYCOLOGY

F. D. Weidman, Chairman	C. W. Emmons
R. W. Benham	J. G. Hopkins
A. L. Carrion	A. Howell, Jr.
N. F. Conant	

## REPRESENTATIVES ON COUNCIL A. A. A. S. (1944)

Chas. Thom

E. M. Gilbert

## REPRESENTATIVE TO NATIONAL RESEARCH COUNCIL

N. E. Stevens

## REPRESENTATIVES TO COUNCIL UNION OF AMERICAN BIOLOGICAL SOCIETIES (1944)

J. S. Karling

G. D. Darker

## REPRESENTATIVE TO EDITORIAL COMMITTEE AMERICAN JOURNAL OF BOTANY

L. R. Hesler

## FINANCIAL STATEMENT

December 31, 1942-December 31, 1943

## Balance on hand December 31, 1942:

Cash.....	\$ 756.33
Government bonds.....	200.00
Savings account.....	600.00

## Receipts:

Annual dues in part 1943, 1944.....	1,659.67
Interest on savings account.....	11.31

## Expenditures:

New York Botanical Garden for Mycologia.....	\$1,336.00
Returned checks and discounts.....	11.39
Postage and envelopes.....	24.69
Secretarial help.....	15.75
Mimeographing and printing.....	5.76
Refunds to members.....	2.00
Binding Society archives.....	9.15
Bank service charges.....	4.46

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\$1,409.20

## Balance on hand, December 31, 1943:

Cash.....	636.80
Government bonds.....	940.00
Savings account.....	241.31

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\$3,227.31    \$3,227.31(signed) GEORGE B. CUMMINS, *Secretary-Treasurer*

## Examined and found correct:

(signed) H. C. GREEN, *Chairman of Auditing Committee*

Jan. 10, 1944

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<sup>1</sup> This index was prepared by Gussie Mildred Miller.

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